Model 210UV NanoSpec®/AFT

UV Very Thin Film Measurement System

Operations Manual
Model 210 / 210VT / 210UV

NANOMETRICS

NANOMETRICS

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INSTALLATION REPORT

Customer/Company Name	System Model No.	Serial No.	Install Date
AT&T Bell Labs	7200-1821 Rev A	1191-H10127	1/22/92

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Street Address
Murray Hill, NJ 07974
City State Zip

Contact Name:	Title:
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Phone No.	PO #
908-582-2606	

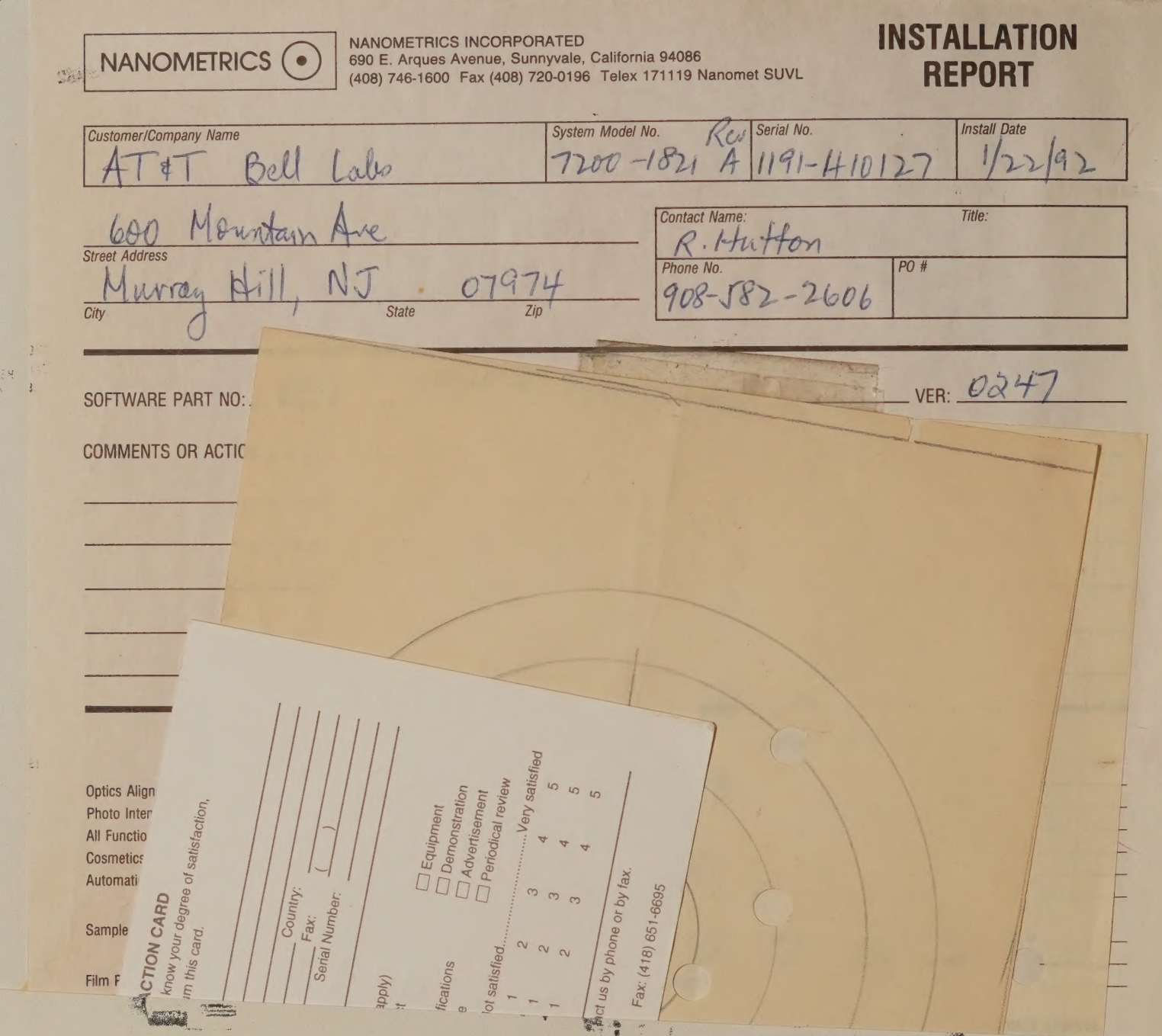
SOFTWARE PART NO: VER: 0247

COMMENTS OR ACTIO

Optics Align
Photo Inter
All Functio
Cosmetics
Automati

Sample

Film F



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NanoSpec®/AFT

Automated Film Thickness
Measurement System

Operations Manual
for the
Nanometrics
NanoSpec/AFT Models 210/210VT/210UV

Manual Part Number: 7500-0608-B

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Revision B
9 8 7 6 5 4 3 2 1

Federal Communications Commission Radio Frequency Interference Statement

This equipment generates and uses radio frequency energy and if not installed and used properly, that is, in strict accordance with the manufacturer's instructions, may cause interference with radio communications. It has been type tested and found to comply with the limits for a Class A computing device in accordance with the specifications in Subpart J of Part 15 of FCC Rules, which are designed to provide reasonable protection against such interference when operated in a commercial environment. Operation of this equipment in a residential area is likely to cause interference, in which case the user at his own expense will be required to take whatever measures may be required to correct the interference. (FCC, Part 15.818a)

Instructions to User

If this equipment does cause interference to radio or television reception, which can be determined by turning the equipment on and off, the user is encouraged to try to correct the interference by one or more of the following measures:

- ✔ reorient the receiving antenna
- ✔ relocate the equipment with respect to the receiver
- ✔ move the equipment away from the receiver
- ✔ plug the equipment into a different outlet so that computer and receiver are on different branch circuits.

If necessary, the user should consult the dealer or an experienced radio/television technician for additional suggestions.

The user may find the following booklet prepared by the Federal Communications Commission helpful: *How to Identify and Resolve Radio-TV Interference Problems.* This booklet is available from the U.S. Government Printing Office, Washington DC 20402. Stock No. 004-000-00345-4.

About This Manual

This manual provides the information you need to operate and program tests for a Nanometrics Models 210/210VT/210UV NanoSpec/AFT automated film thickness measurement system.

How To Use This Manual

This manual covers Models 210/210VT/210UV operator and process engineer procedures, including power up and initialization, calibration, and programming tests. The manual is divided into the following chapters:

Chapter 1, **Introducing the NanoSpec/AFT Models 210/210VT/210UV,** gives an overview of the Models 210/210VT/210UV, its capabilities, system components, controls and indicators, and specifications.

Chapter 2, **Getting Started,** covers precautions, preoperational procedures, power on, and initialization procedures.

Chapter 3, **Operator Procedures,** explains everything you need to know to operate the NanoSpec/AFT Models 210/210VT/210UV, including running measurement test programs, and displaying and printing measurement data.

Chapter 4, **Technical Overview,** explains how the Models 210/210VT/210UV measures films by reflectance of light and interference of wavelengths. This information is important to Process Engineers who must design custom measurement programs for the instrument.

Chapter 5, **Process Engineer Procedures,** describes the responsibilities of the process engineer and explains how to gain access to Process Engineer mode. It explains how to create and edit measurement test programs. This chapter also covers statistics procedures.

Chapter 6, **Overview of Options,** explains the use of each of the optional devices available for the Models 210/210VT/210UV.

Chapter 7, **Troubleshooting and Maintenance,** gives guidance if any problems occur and necessary maintenance for the 210/210VT/210UV.

Operators should read chapters 1 through 3, and then consult chapter 4 as necessary to check on the details of individual functions. **Process Engineers** should read at least chapters 1 through 5 to become thoroughly familiar with the instrument. Both operators and process engineers should read chapter 6 to familiarize themselves with any options.

Manual Conventions

Following are the typographic conventions used in this manual:

Key Names

The names of keys on the computer keyboard are spelled out and appear in angle brackets:

<Esc>, <Enter>, <Ctrl>, <MEAS>, <CALIB>

Key Combinations

A plus sign between two or more key names means that you must press the first key and, while holding it down, press the next key. For example,

<Ctrl> + <MEAS>

means press the **<Ctrl>** key and hold it down, then press the **<MEAS>** key and hold it down. As soon as you have completed these steps, you can release all keys.

What You Type

Commands that you should type exactly as they appear are shown in a bold typewriter style. For example,

```
INSTALL <PRNTR>
```

means type **prntr** and then press **<Enter>.**

What you See

Information displayed by the computer, AFT head readouts, and test equipment readings are shown either by an illustration of the actual display or in a typewriter style:

```
"Zero Check"

"Measuring Reference"
```

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Chapter 1

Introducing the NanoSpec/AFT Models 210/210VT/210UV

The Models 210/210VT/210UV NanoSpec®/AFT Automated Film Thickness Measurement System (hereafter referred to as the Models 210/210VT/210UV) are instruments designed to measure the thickness of films deposited on semiconductor wafers during wafer manufacturing processes. The Models 210/210VT/210UV provide accurate, repeatable, hands-off measurement in a cleanroom environment.

The following topics are covered in this chapter:

- ✔ System Features
- ✔ Specifications
- ✔ System Components
- ✔ Controls and Indicators

System Features

The NanoSpec/AFT offers these important features:

- Small spot size
- Fast measurements
- Broad thickness ranges
- Precise thickness values
- 20 specific film programs
- Customized film programs
- Comprehensive statistics programs
- Relative reflectance
- Multipurpose thick film capability
- UV or VT capabilities to measure very thin films

The range of the Model 210 extends from 100 to 500, 000 Å (50 micrometers). The Model 210VT allows measurements to 20 Å. The Model 210UV allows measurements to 10 Å.

Specifications

Specifications for the Models 210/210VT/210UV can be divided into wafer specifications, measurement specifications, environmental specifications, and installation site specifications.

Measurement System

Thickness range
100Å to 500,000Å
down to 10Å using UV system
down to 20Å using VT system

Measurement spot sizes

Visible Light *(210UV in visible)*	5X objective lens	50μm (30μm) spot size
	10X objective lens	25μm (15μm) spot size
	50X objective lens	5μm (3μm) spot size
	100X objective lens (optional)	2.5μm spot size
VT	1mm x 4mm spot size	
Ultraviolet Light	10μm spot size	

Measurement time

Visible Light	2.5 seconds
VT	0.3 seconds
Ultraviolet Light	10 seconds

Film types

Visible Light	oxide on silicon	nitride on silicon
	negative resist on silicon	polysilicon on oxide
	negative resist on oxide	nitride on oxide
	thin oxide on silicon	thin nitride on silicon
	polyimide on silicon	positive resist on silicon
	positive resist on oxide	red resist on silicon
	thick films	
VT	very thin oxide on silicon	very thin nitride on silicon
Ultraviolet Light	very thin oxide on silicon	very thin nitride on silicon
	oxide on polysilicon on anything	oxide on aluminum

Wafer Specifications

Wafer size
3" (75mm), 4" (100 mm), 5" (125 mm), 6" (150 mm), 8" (200mm) optional

Installation Site Specifications

Location	Any table top surface void of excessive vibration (whether mechanically or acoustically induced), and void of electromagnetic and magnetic fields	
Power	primary:	117 volts ±5%, 50/60Hz
	power dissipation: (UV & VT)	250 watts
	laser power output:(VT)	6328A HeNe Laser <1mW

System Dimensions
(width x depth x height)

Microscope & Spectrophotometer	30-5/8" x 24-1/2" x 20"	
Computer CS-3/CS-5	9-1/2" x 7-1/2" x 21-1/2"	
CRT Terminal	14" x 13-1/2" x 13-1/2"	
CRT Keyboard	2" x 18-1/2" x 8"	
Optional Clean-room Printer	3-1/8" x 7-3/8" x 6-1/2"	
Optional Chart Recorder	4-3/4" x 9" x 10-1/2"	
Laser Power Supply (VT)	2-1/2" x 8" x 6-1/2"	

Weight

Microscope & Spectrophotometer	Model 210	49 pounds
	Model 210VT	51 pounds
	Model 210UV	64 pounds
Computers	17 pounds	
CRT Terminal	20.2 pounds	
CRT Keyboard	3.2 pounds	
Optional Clean-room Printer	3.5 pounds	
Optional Chart Recorder	7.5 pounds	
Laser Power Supply (VT)	0.5 pounds	

Environmental Specifications

Operating temperature	45°F to 80°F (7°C to 27°C)
Humidity	20% to 80%, noncondensing

System Components

Computers

All models include a Nanometrics-built microcomputer, based on the Intel 8085 microprocessor. The Model 210 and 210VT use the CS-3 computer, while the Model 210UV uses the CS-5 computer. Two standard RS-232C ports are available for connecting external equipment.

Microscope & Spectrophotometer

The spectrophotometer head is mounted on a customized microscope with vertical reflected light illumination, using a regulated tungsten lamp, variable field diaphragm, and 5X, 10X and 50X parfocal objectives, mounted in a five-position turret. An optional 100X objective lens is available. The lens viewer has a measuring aperture 0.25 ±0.1 mm in diameter, and a monocular with a 10X eyepiece for precisely locating micro-areas to be measured.

Stages

Different stage sizes (100 x 100 mm, 125 x 125 mm, 150 x 150 mm, or 200 x 200 mm), for 3 to 8 inch wafers are available.

CRT Terminal

Displays menus, commands and instructions.

Keyboard

Operating, programming and maintenance procedures are performed by using a CRT keyboard. The keyboard features 12 programmable function keys, separate cursor control arrow keys and a numeric keypad.

Ultra Station Option

A tweezer/vacuum probe free wafer loader.

Optional Printer

Measurements and statistical results may be printed on a clean room compatible printer, available as an option.

Model 210VT only:

Microscope

Using a helium-neon laser as a light source, the Model 210VT can produce accurate measurements down to 20Å. The 0.5mW laser is located under the covers on the side of the microscope. The laser complies with 21-CFR-1040. It is a Class II laser. The 210VT uses a 1mm x 4mm spot size when measuring VT films

Laser Power Supply

A separate laser power supply is attached by a cable. The laser power supply has a key-lock power switch that should normally be turned on.

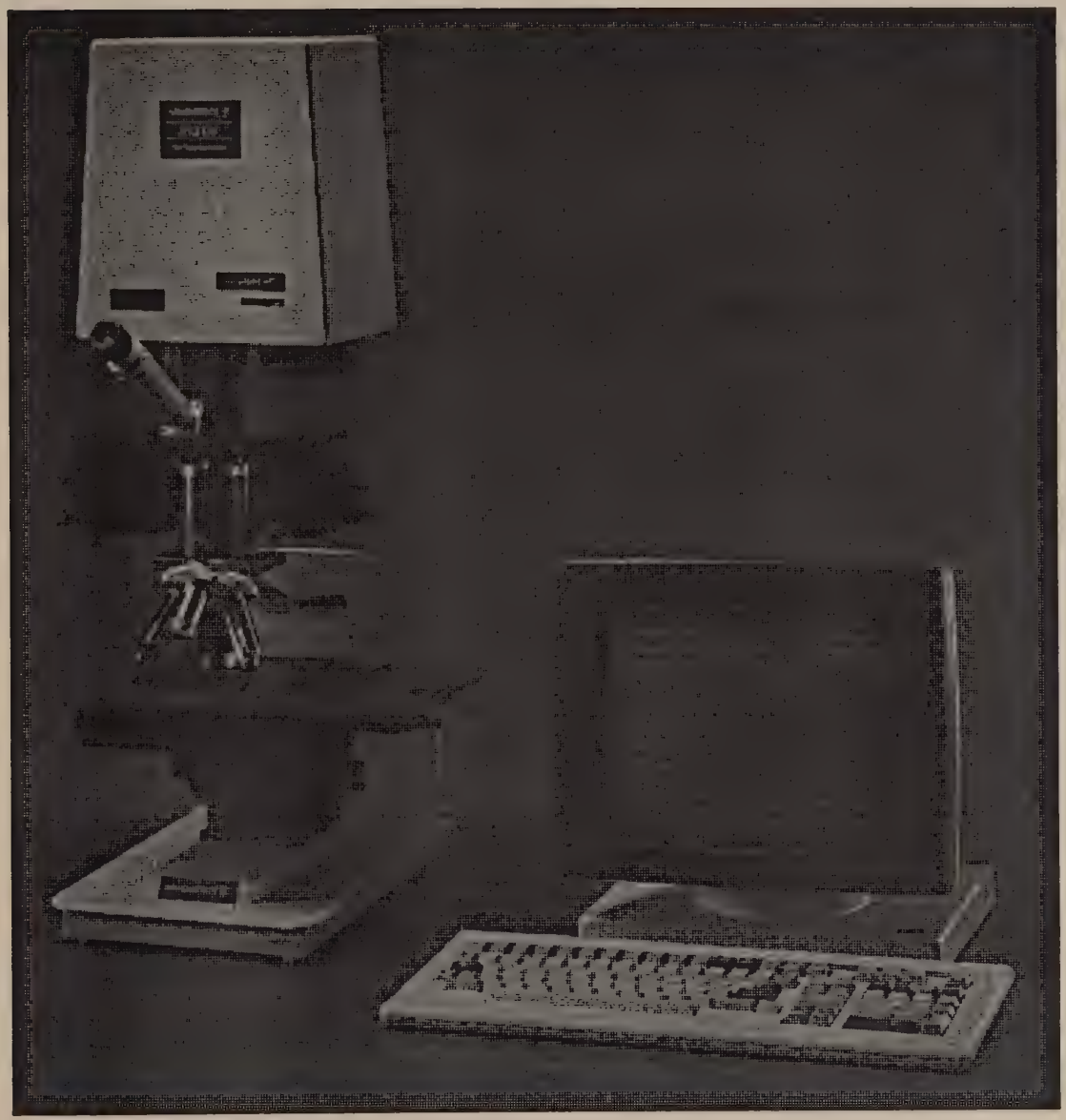
Model 210UV only:

Microscope

The Model 210UV works by reflecting visible and ultraviolet light off the surface of a measurement sample through a specially designed microscope. The visible light source is a regulated halogen lamp that has been optically engineered and focused. The use of ultraviolet light generated by a deuterium lamp allows thinner films to be measured down to 10Å. The 210UV uses different objective lenses: 30, 15 and 3 micron spot size in visible light and 10 micron spot size in ultraviolet light.

UV Power Supply

A separate UV power supply is attached by a cable. The UV power supply has a key-lock power switch that should normally be turned on.



Model 210UV

Controls and Indicators

Controls and indicators are located in several places, including the computer, the Spectrophotometer head, the CRT terminal and the keyboard.

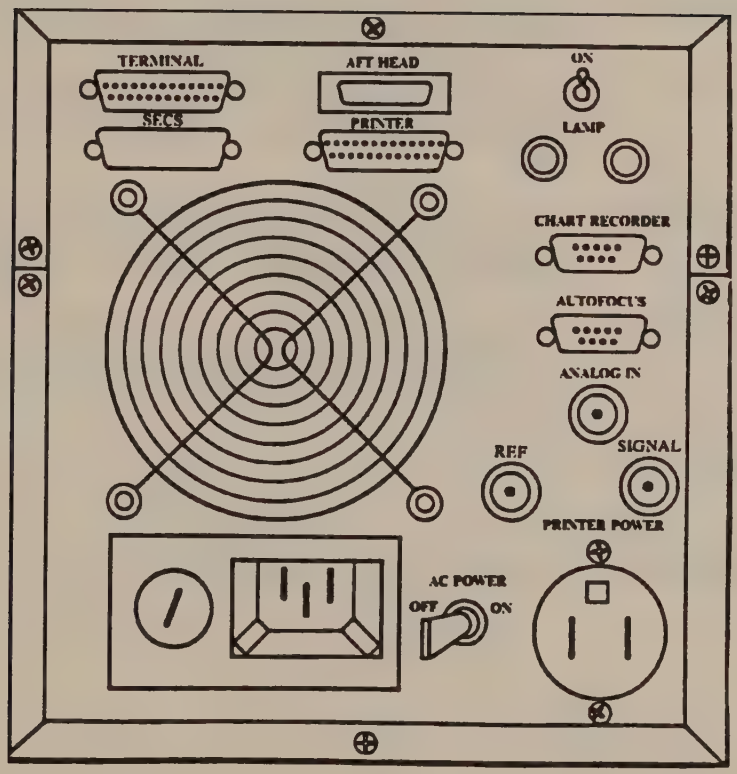
Computer

Main Power Switch

The main power switch of the NanoSpec/AFT system is located at the lower rear of the computer.

Lamp Switch

The lamp switch is located on the rear panel of the computer. Turn it on immediately after powering up the system.


TERMINAL
SECS
AFT HEAD
PRINTER
ON
LAMP
CHART RECORDER
AUTOFOCUS
ANALOG IN
REF
SIGNAL
PRINTER POWER
AC POWER
OFF
ON

Rear Panel

Microsope/Spectrophotometer

See the figure on the opposite page.

Wavelength Display

The front panel of the spectrophotometer head includes a wavelength display at the lower right.

Photointensity Display

The front panel of the spectrophotometer head also includes 4 digit photointensity display at the lower left.

Gain Control

There is a Gain Control feature on the spectrophotometer head. The Gain Control is accessible through the open left end of the black cover, beyond the zero adjustment.

Zero Adjustment

There is a Zero Adjustment feature on the spectrophotometer head. The Zero Adjustment control is just inside the open left end of the black cover.

Note: The purpose of the black cover is to prevent the accidental changing of controls. The left end of the cover is open, and the Gain Control can be reached through the opening. Be careful not to change the Zero Adjustment while reaching past it.

Field Diaphragm

The Field Diaphragm control is a small lever, marked F, directly behind the viewer on the vertical illuminator. All measurements should be made with the diaphragm closed (the lever in its clockwise position).

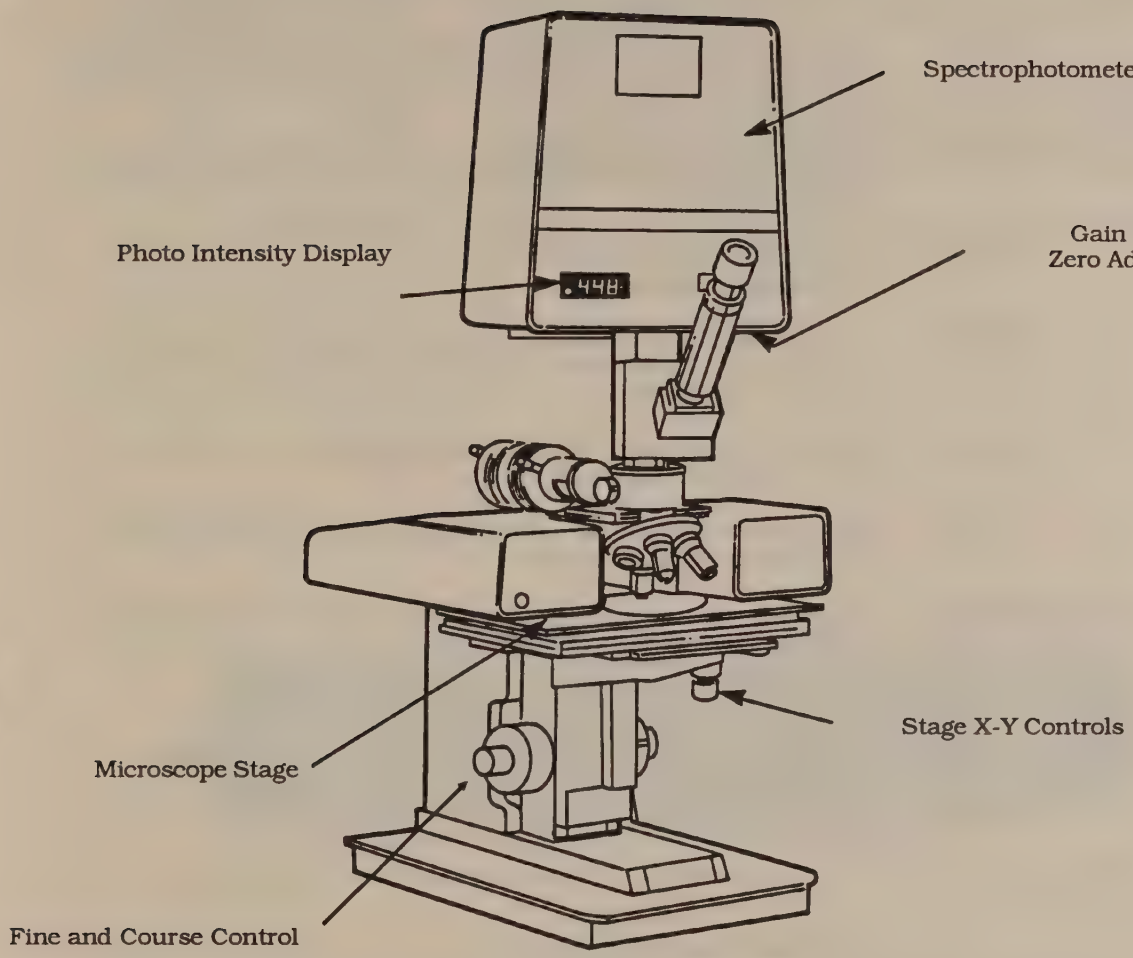
Yellow Filter

A yellow filter is dropped into the vertical illuminator. Its cut-on wavelength is 460 nm, passing light of longer wavelength and blocking shorter wavelengths. The filter is normally left in the light path, except for certain measurements that require its removal.

CRT Terminal

Power Switch

The power switch for the terminal is located at the bottom right front of the unit



Microscope and Spectrophotometer Head

Keyboard

Most of the regularly used controls are on the keyboard of the CRT terminal. There are special keys designed by Nanometrics, in addition to the standard keys.

CALIB This key stops any measurement in process and returns to the Available Programs screen. This gives the operator an opportunity to choose another program, objective lens or to run a new reference scan.

NEW TEST This key initiates a new measurement sequence with a new sample using a previously selected test program. A zero check is generally made and a new sample ID may be entered by the operator.

ENTER This key terminates an alphanumeric entry. The computer has not received the data until **<Enter>** is pressed.

MEAS This key initiates a measurement. It can also be used to repond to a prompt requiring a "Yes" answer. Holding down the **<MEAS>** key causes the system to make continuous measurements.

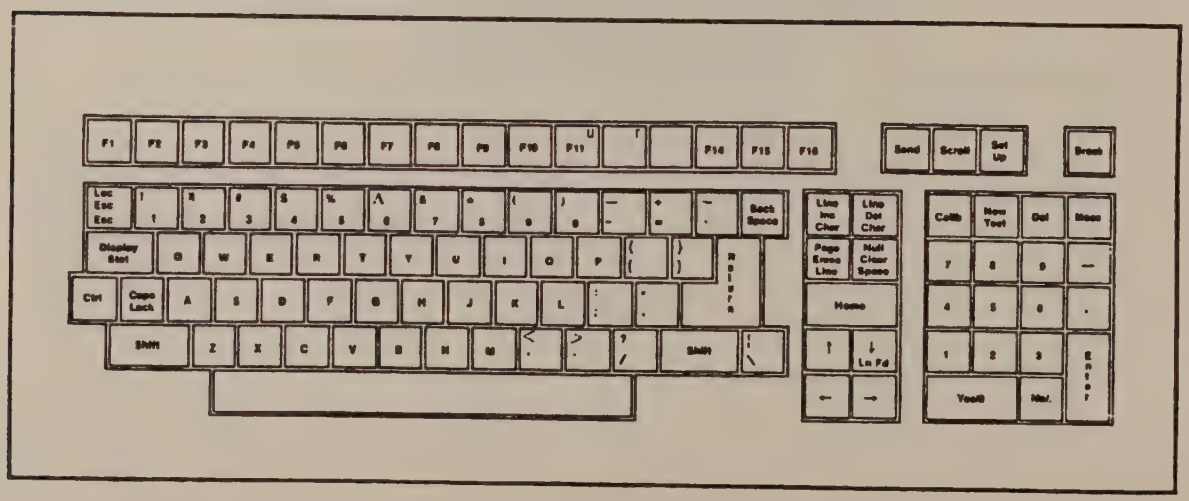
YES/0 This key is used to respond "Yes" to certain prompts ending with a question mark, or as the zero digit in a numerical entry.

NO/. This key is used to respond "No" to certain prompts ending with a question mark, or as a decimal point in a numerical entry.

DISPLAY STATISTICS This key is used to display statistics for measurements taken on an individual sample during a measurement session.

UNDERLAYER ON/OFF This key enables measurement of the bottom layer on a dual layer film.

REF INDEX ON/OFF This key enables measurement of the refractive index.



Model 210VT only:

Laser Radiation Emission Indicator

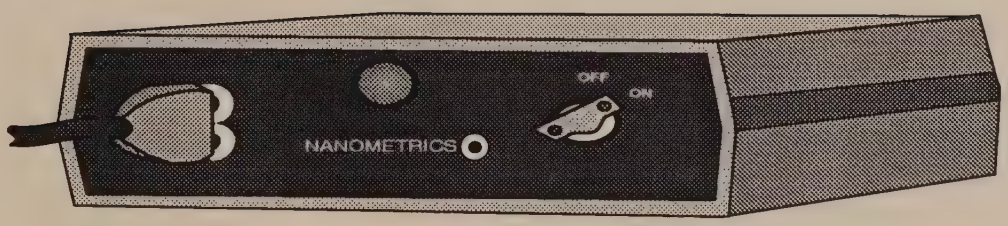
There are 2 emission indicator lights on the 210VT, one on the power supply and the other on the microscope. The emission indicator lights immediately when the key control is turned on.

Laser Beam Shutter Control

This control, located to the left of the objective lenses in front of the aperture warning labels, controls a shutter that prohibits laser radiation in excess of the emission limits. **Keep the shutter in its closed position at all times when the laser measurement system is not being operated.** Open it to run Test Programs 15 and 16.

Key control

The laser power supply is activated when the key is turned to the "ON" position. A 3 second time delay occurs before the laser is activated.



VT Laser Power Supply

Chapter 2
Getting Started

The Models 210/210VT/210UV were installed and calibrated by a trained factory representative and are ready to use. This chapter explains how to power up the instrument in preparation for use. The information in this chapter is important both to operators and process engineers.

The following topics are covered in this chapter:

- ✔ Precautions
- ✔ Preparation and Setup procedures
- ✔ Power on/off procedures
- ✔ The reference sample wafer
- ✔ Instrument initialization procedure
- ✔ Focusing

Precautions

Model 210UV

Using ultraviolet light creates the need for extra safety precautions to be taken when working with the system.

UV

Ultraviolet light is harmful to the eyes and skin. The Model 210UV is safe under normal operation or during the lamp plasma position adjustment, but extreme caution should be taken when the cover of the D_2 lamp is removed and the lamp power is on.

Caution: UV goggles must be worn when the D_2 lamphouse is open.

Ozone

Ozone is produced by the UV ionizing the oxygen. The levels found after testing the Model 210UV are well within OSHA guidelines. The system should be placed in a room with adequate ventilation, such as a standard clean room environment.

D_2 Lamp

The D_2 lamp takes 15 minutes to stabilize after it is turned on. After it is shut off, wait 5 minutes prior to turning it back on. Not doing this will shorten the life expectancy of the lamp, and the lamp may not turn on. If no light comes on, turn the lamp off for 5 minutes, and turn it on again.

◆ **Warning:**

The D2 lamp should be handled with unpowdered gloves. Finger oils and acid will reduce lamp life. Lamp may explode if finger printed.

Model 210VT

The Model 210VT contains a 0.5 mW laser. All persons who work with or near the system should be made aware of the potential hazards of lasers.

Helium - Neon Laser

The use of optical instruments with this product will increase eye hazard. Use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.

◆ **Warning:**

When working with the Model 210VT, never look directly into the laser beam.

Voltages

The laser head starting and operating voltages are lethal. If access to the laser power supply is necessary, make sure that the power supply is turned off and unplugged. If it is necessary to operate the laser head while the interior of the power supply is exposed, use extreme caution to avoid exposure to high voltages.

Warnings

- Moving parts may catch loose clothing.
- Turn off power and disconnect unit before performing assembly/disassembly.

Turning On the Instrument

To turn on the instrument, follow these steps:

1. Turn on the CRT terminal if it hasn't been turned on.
2. Turn on the power using the on/off switch located on the lower rear of the computer.

Next you must initialize the instrument. First, however, you must have an appropriate reference wafer.

Obtaining a Reference Sample Wafer

The next operation you must perform is to initialize the system. This involves taking a reference. Several times during routine operation, you'll be instructed to take a reference before proceeding.

It is the Process Engineer's responsibility to produce reference sample wafers for specific applications. In general, the reference sample is a clean, bare silicon wafer carefully store for use as needed.

Initialization

Whenever you turn on power, the system must be initialized. Follow these steps to initialize the system:

1. With the logo screen displayed, the following prompt appears:

Press **<Yes>** if you would like the SECS II Datalink enabled?
Press **<No>** if you don't want to use the communications interface.

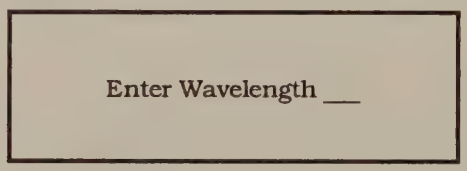
3. You are prompted to check the starting wavelength and set if necessary:

The instrument must begin its scan at 480 namometers, but since this is an initialization, the wavelength display may not read 480.

a. Press **<Yes>** if the counter reads 480.

or

b. Press **<No>** to change the counter value if it doesn't read 480. The following prompt appears:



Type the number appearing on the wavelength counter and press **<Enter>**. Only type a 3 digit number. Return to Step a.

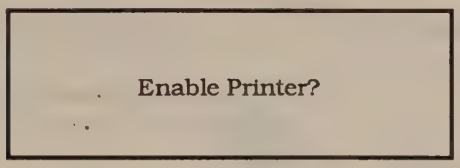
Note: If at anytime, the wavelength counter does not start its scan at 480, it can be reset without rebooting the system by typing **SWAVE** while pressing **<Ctrl>**.

4. Next, you are prompted to enable or disable the refractive index prompt:

With the refractive index feature, it is possible to specify a refractive index different from the normally assumed values.

Press **<Yes>** to enable this feature or **<No>** to disable it.

5. If you purchased the optional printer, the following prompt appears:



Press **<Yes>** to enable the printer or **<No>** if you do not wish to use it.

When the printer is enabled, the following information is printed for each measurement program used:

Program name
Objective lens
Accepted measurements

User program descriptions and user program statistics are also printed where appropriate in instrument operation.

The printer can be enabled or disabled at a later time by typing **PRNTR** while pressing **<Ctrl>**. This can be used to turn the printer on or off at any time.

How to Focus

Read the following procedure on focusing prior to performing the preoperational procedures.

Focusing

1. Look into the instrument's eyepiece. If the instrument is not focused, a large round spot with blurred edges is seen.

2. Using the focus adjustment knobs, course and fine, located on the microscope stand, focus until the circle with the blurred edges turns into an octagon (8 sides) shape with sharp clear edges. In the middle of this octagon there is a black dot. The system measures the area inside this black dot.

3. When measuring a patterned wafer, move the wafer so that the black dot is in the center of the feature to be measured.

   When measuring an unpatterned wafer, move the wafer so that the black dot is in the area to be measured.

HINTS

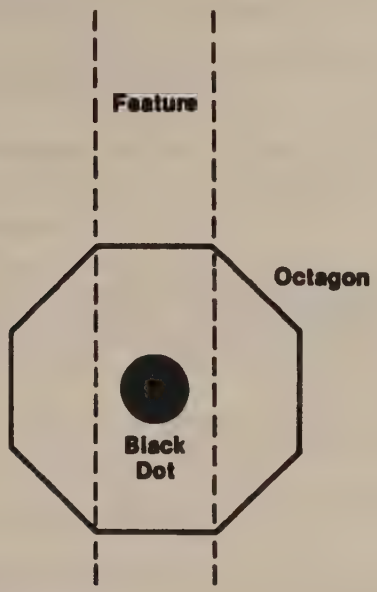
1. If a certain feature is difficult to find, the Field Diaphragm located on the microscope vertical illuminator may be used. This control enlarges the octagon area seen through the eyepiece. When the desired feature is found, make sure to retun the Field Diaphragm to its closed position or erroneous answers may result.

2. It is also useful to use a lower powered objective to find the general area of a feature. When it has been found, change to the correct objective for the test program.

   The chart below shows the relationship between objective lens and measurement size.

		Standard 210	210UV
Objective Color Code	**Lens Power**	**Dot size (microns)**	**Dot size (microns)**
Red	5X	50	30
Yellow	10X	25	15
Blue	50X	5	3
White	100X	2.5	----
Black	15X	-----	10

3. If the black dot is larger than the feature to be measured, use a higher powered objective lens. The black dot must be smaller than the feature to be measured and must not be located on its edge. The following diagram illustrates the view through the eyepiece when it is correctly focused and located on a feature to be measured. The feature is represented by the parallel lines that go through the octagonal shaped area.



Critical Focusing

Critical focusing for optimum results on unpatterned wafers using the 10X objective is especially important for films under 200Å.

A technique has been developed for reproducible focusing on unpatterned wafers using the 10X objective with Test Programs 7 and 8. This will result in a more precise measurement.

1. At the point in the program when focusing is required, put the 50X objective into place.
2. Focus on the feature with this objective.
3. Switch the objective back to the 10X.
4. Without refocusing, take the measurement.

◆ **IMPORTANT:** The reference scan on bare silicon must be made using this same focusing technique.

It is extremely important for the system to be properly aligned and for the objectives to be par-focal. Contact Nanometrics' Service Department for the proper alignment procedure.

Preparation & Setup

Set Gain Control

Allow 30 minutes for the instrument to warm up, then perform the following procedures:

1. Drop the yellow filter into the vertical illuminator. Leave the filter in this position unless directed to change it.

2. Place a bare silicon reference wafer on the stage. Follow the directions in the window.

> Focus on Reference with 10X Objective Lens
>
> Adjust Gain Control so that
>
> Photo Intensity Meter Reads between 65.0 and 67.0
>
> Repeat Procedure as Necessary
>
> Press **Enter** to continue

3. Select the 10X objective lens on the machine. Focus on the reference.

   See the previous section for information on how to focus.

4. Adjust the Gain Control knob until the Photo Intensity Meter displays a reading between 65.0 and 67.0

   The Gain Control is located inside the cover under the spectrophotometer head. Adjust it by inserting a forefinger in the open left end of the cover.

5. Press **<Enter>** when complete.

NOTE: The gain can be adjusted without resetting the system by typing **SETGN** while pressing **<Ctrl>**. The above window will appear. Follow the instructions.

The following procedures are for the Model 210UV only.

Using ultraviolet light creates the need for preoperational alignments and testing. Please perform the following procedures to setup your system and for periodic checks.

Use the procedures found in Chapter 3 of this manual to aid in performing the following preoperational alignments and testing.

D_2 Lamp Plasma Position Alignment

CAUTION: Prior to performing any alignments, the D_2 lamp must be turned on for 15 minutes in order to warm up.

1. Using the 15X objective lens, place the bare silicon wafer or calibration wafer into the pocket on the stage. Focus on the sample.

   Focus the sample:

   Due to the requirement for the UV and visible light having to pass through the optical path, a special beam splitter is installed inside the microscope. This produces a slight double image on the diaphragm, except at the top right hand side corner. Bring this clear corner into focus. As the new thin film algorithm is not sensitive to focus error, perfect focus is not needed to do the measurement.

2. Block the visible light beam by putting a beam blocker into the slot near the Cut-On filter. Observe the UV plasma through the eyepiece.

3. Run Test Program #12. When prompted select a single wavelength at 270 nm. This monitors the reflectivity of the system.

4. Adjust the x position knob to obtain the maximum reading at the intensity meter. Then adjust the y position knob to obtain the maximum reading at the intensity meter. Finally, adjust the z position knob to obtain a maximum reading at the intensity meter.

5. Check the Photo Intensity Meter. If the Gain has been set, at 270nm the Photo Intensity Meter must read 15 or more. If it doesn't, use another bulb.

6. Remove the visible beam blocker. Make sure the sample is still focused. If not, redo steps 1 through 5. The best intensity of UV is at the best visible focus point.

Halogen Lamp Alignment

1. Again run Test Program #12. When prompted select a single wavelength at 520 nm.
2. Measure a bare silicon reference. The reading should be 100%.
3. To provide correction for $\geq$ 100%, move the two adjustment knobs controlling the horizontal and vertical axes of the Halogen lamp.
4. Repeat the measurement. Observe the reading. Successful alignment will maximize the reading.
5. Repeat steps 3 and 4 until the reading is at its highest point (greater than 100%).

D_2 Lamp and Halogen Lamp Test

To ensure that the lamps are working properly, run the following test:

1. Using the 15X objective lens, run Test Program #12.
2. Enter 270 nm, 520 nm and 780 nm for the wavelengths. Measure the reflectance 10 times.
3. The results should be

   270 nmless than 0.2% standard deviation

   520 nmless than 0.15% standard deviation

   780 nmless than 0.2% standard deviation
4. If the 270 nm is out of spec, the D_2 lamp either needs to be replaced or the plasma is not properly aligned. If the 520 nm or 780 nm is out of spec, the Halogen lamp either needs to be replaced or the filament position needs to be adjusted to obtain better efficiency.

Turning Off the Instrument

To turn off the Models 210/210VT/210UV, do the following

1. Remove wafer if there is one loaded.
2. Turn off the power using the on/off switch located on the lower rear of the computer.
3. Turn off the CRT terminal using the switch located on the front of the base.

Resetting

To reset the system, type **RESET** while pressing **<Ctrl>**. This is equivalent to turning the instrument power switch off and then on again. When this is done, there is no need for additional warm up time.

Summary

In this chapter, you learned how to turn on the instrument, perform initialization, preoperational procedures, and turn it off.

The next chapter explains operator procedures—all the operations you need to know to take measurements and display and print measurement results.

Chapter 3
Operator Procedures

With the Models 210/210VT/210UV powered up and initialized, you are ready to begin taking measurements. This chapter explains operator procedures, including:

- ✔ Measuring Wafers
- ✔ Invoking a Test
- ✔ Understanding messages
- ✔ Printing measurement results
- ✔ Reflectance Mode
- ✔ Determination of Underlayer Thickness
- ✔ Determination of Refractive Index
- ✔ Displaying Statistics
- ✔ DataLink II

Whether you are an operator or a process engineer, you need to understand the information in this chapter to operate or program the Models 210/210VT/210UV.

Measuring Wafers

This section explains how to invoke a measurement test program, and how to interpret messages that appear in the measurement table.

Invoking a Test

To invoke a test, first be sure the Available Programs Menu is displayed:

```
                    Available Programs

-------------------------------------------------------------
Standard programs          User defined programs
-------------------------------------------------------------

 1 Oxide on Silicon        51 unused      67 unused
 2 Nitride on Silicon      52 unused      68 unused
 3 Neg Resist on Silicon   53 unused      69 unused
 4 Polysilicon on Oxide    54 unused      7Ø unused
 5 Neg Resist on Oxide     55 unused      71 unused
 6 Nitride on Oxide        56 unused      72 unused
 7 Thin Oxide on Silicon   57 unused      73 unused
 8 Thin Nitride            58 unused      74 unused
 9 Polyimide on Silicon    59 unused      75 unused
1Ø Pos Resist on Silicon   6Ø unused      76 unused
11 Pos Resist on Oxide     61 unused      77 unused
12 Reflectance Mode        62 unused      78 unused
13 Thick Films             63 unused      79 unused
14 EPA914EZ Resist on Si   64 unused      8Ø unused
                           65 unused      81 unused
                           66 unused      82 unused

    Enter Program Number __

    Enter Objective Lens  (Ø = 5X, 1 = 1ØX, 2 = 5ØX, 3 = 1ØØX
```

If a different screen is displayed, press **<Calib>**.

Programs 1 - 14 are standard tests using visible light. The 210VT contains programs 15 and 16 for very thin film measurement. The 210UV contains programs 17 - 20 for measurement utilizing an ultraviolet light source.

◆ **IMPORTANT:** If you are going to run a test that requires UV on the Model 210UV, make sure that the D_2 lamp has been turned on for at least 15 minutes prior to operation.

◆ **IMPORTANT:** If you are going to run a test that requires VT on the Model 210VT, make sure that the Laser Beam Shutter is open. **If you are not running tests 15 or 16, it must be closed!**

To begin measurement, do the following:

1. Select the Program Number of your choice. See the Program Notes section of Chapter 4 for information on program selection.

2. After you specify a test to execute, enter the objective lens to be used for film measurement.

Enter Objective Lens ____ (0=5X, 1=10X, 2=50X, 3=100X)

Program 13 will only allow selection of the 5X or 10X objective lens.

This prompt is not seen when running the UV Programs, 17 - 20, which only use the 15X objective lens and Program 12, Reflectance Mode, which only uses the 10X objective lens.

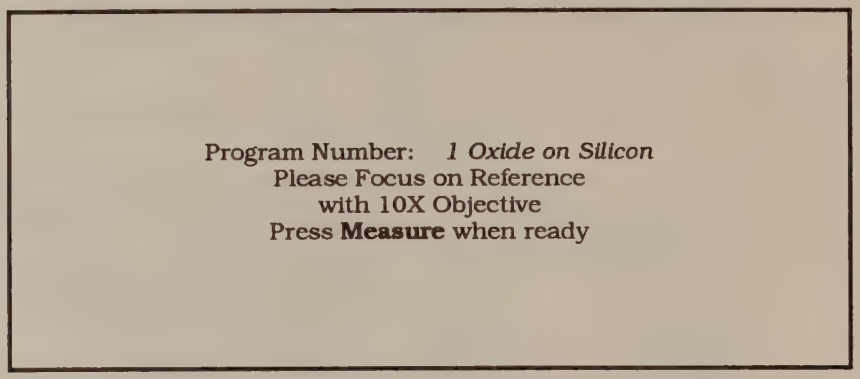
* The choice for the 100X lens will appear only if that option was purchased for your system.

◆ **IMPORTANT:** Remember to manually switch the instrument to the selected objective lens prior to actual measurement.

Referencing

If this is the first time you are running a program since turning on the machine, a reference must be taken. Otherwise, skip to Step 7. See the Program Notes section in Chapter 4 for information on referencing and reference wafers.

1. Place the appropriate reference sample under the microscope. Following the instructions in this Reference Window, focus on the reference wafer.



   Make certain that the 10X objective lens is selected on the machine for all programs other than the UV programs, 17 - 20. UV programs require that the 15X lens be used instead.

   NOTE: For Programs 7 and 8, thin films, more repeatable focusing can be obtained with the 10X objective lens if you first focus with the 50X lens and then switch to the 10X. Do not refocus the 10X lens.

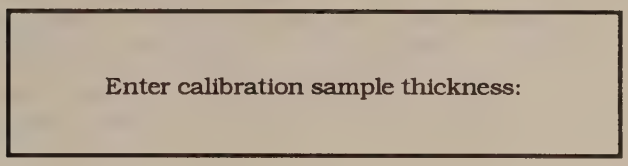
   This is discussed in Chapter 2 - *Critical Focusing*.

2. Press **<Meas>** to measure the film thickness of the reference.

   The system will display the messages: ***"Zero Check"*** and then ***"Measuring Reference"***.

3. Remove the reference. Begin the Measurement procedures unless you are taking a VT reference.

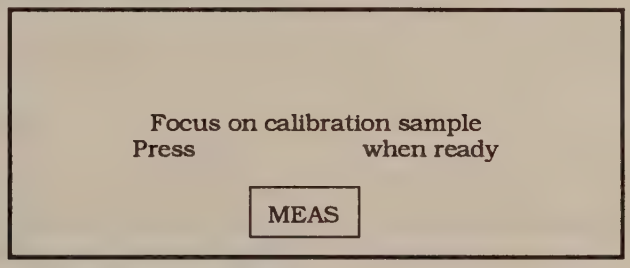
4. For very thin film measurements it is also necessary to perform a calibration at this time. The following prompt appears:



5. Enter the thickness of the calibration sample in Angstroms.

   NOTE: For best results, with this program use films between 400 and 450 Angstroms for the calibration sample. Use of the wafer "CAL-PAC" is recommended. (See Chapter 6 for more information on this option.)

6. Following the instructions on the screen, focus on the calibration sample.



   Press **<Meas>** to measure the film thickness of the calibration sample. Remove the calibration sample when finished.

7. If you have already taken a reference, the following prompt will appear:

   Press **<Yes>** if you would like to take a new reference; else press **<No>**. Some film types require that references be taken frequently. Consult the Program Notes section in Chapter 4 for more information.

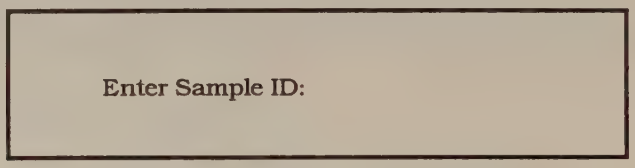
   If you pressed **<Yes>**, return to Step 1, above.
   If you pressed **<No>**, please be sure the 10X objective lens is selected on the machine. The system will display the message ***"Zero Check"*** prior to displaying the next prompt.

   Proceed to the Measurement section.

Measuring

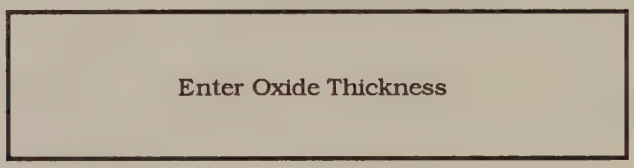
To measure wafers using any of the standard test programs or a user defined program, please follow these procedures:

1. The following prompt appears:



   Enter the Sample ID by typing up to 25 alphanumeric characters, including spaces, if you wish. (Note that capitalization is significant) The Sample ID can be any name or phrase you want to use to refer to this wafer or wafer lot. Consult your process engineer about guidelines for entering the Sample ID. Press **<Enter>** to complete your entry.

2. If the selected test program is 4, 5, 6, 11, or 253 or is a user-defined test derived from one of these tests, the following prompt appears:



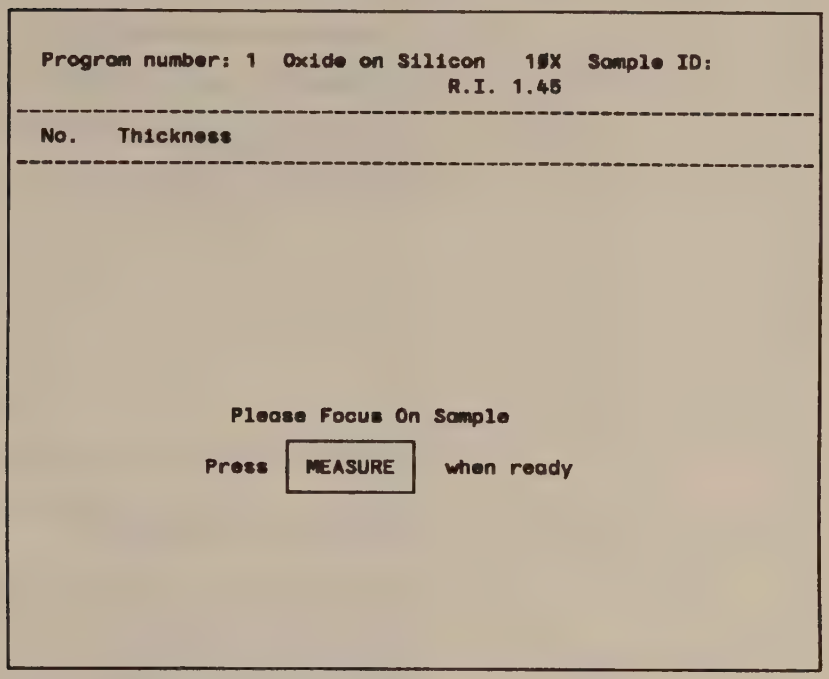
   Type the wafer's oxide thickness in angstroms. Type digits only; do not include the measurement units. The underlayer thickness is the thickness of the oxide layer that was already deposited on the wafer prior to the layer you are measuring. The thickness must be known for accurate measurements of translucent films. Press **<Enter>** to complete your entry.

3. The selected test program specifies a standard refractive index for the material you are measuring. However, if the refractive index option was enabled, the following prompt appears:

   Press **<Enter>** to use the default value specified in the test program, or type the refractive index for the batch of wafers you are measuring, then press **<Enter>** to complete your entry.

   Default values for each test program are found in the Program Notes section of Chapter 4.

4. A Measurement screen similar to the following appears:



Place your wafer on the stage at this time, if you haven't done so already. Locate the area to be measured, using the x and y stage levers.

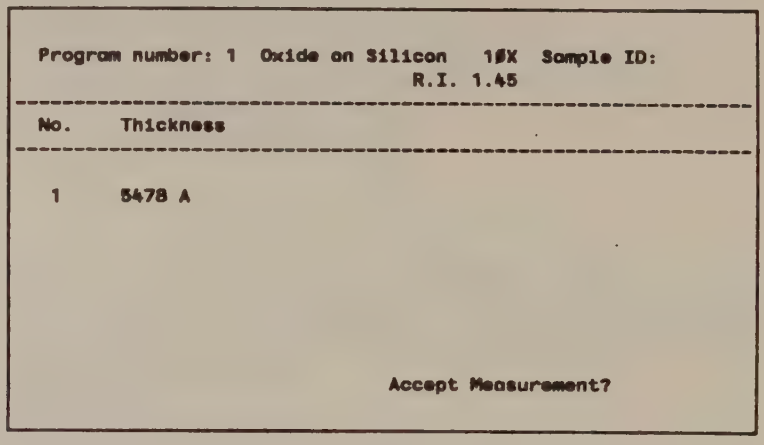
5. Focus on the sample using the objective lens previously selected, displayed in the Measurement Window.

   NOTE: For Programs 7 and 8, thin films, more repeatable focusing can be obtained with the 10X objective lens if you first focus with the 50X lens and then switch to the 10X. Do not refocus the 10X lens.

   This is discussed in Chapter 2 - *Critical Focusing.*

6. Press **<Meas>** when you are ready to measure the film thickness of your wafer. The message ***"Measuring"*** will be displayed on the screen.

7. When the measurement is finished, a Measurement Result screen similar to the following is displayed next.



   This lists the value of the measurement taken in Angstroms. Only the 60 most recent measurements are displayed.

   If the instrument is unable to measure the sample, it will display an error message instead of the measurement value. See the following section on messages for more information. In these cases, the measurement will be automatically rejected. If the test program was user defined, the measurement value is displayed even though it was rejected. Re-position and refocus the sample. Try the measurement again prior to the rejection of the sample.

8. Accept or reject the measurement. Press **<Yes>** to accept the measurement or **<No>** if it is undesirable. Pressing **<No>** results in the message ***"Rejected"*** replacing the measured value.

   The **<Meas>** key will also accept the measurement and then proceed directly to a subsequent measurement.

9. Continue to take as many measurements as needed.

10. To repeat this test on another wafer with a different sample ID, press **<New Test>**. Return to Step 1.

New Test Program

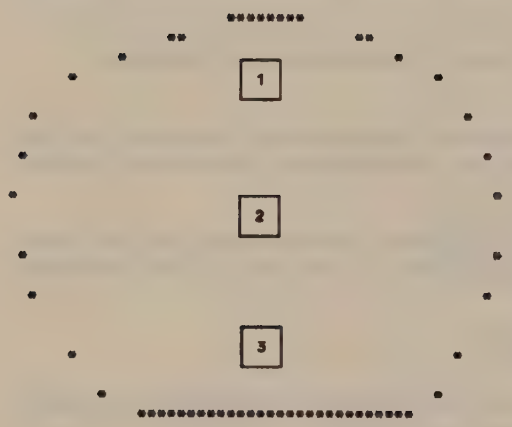
To select a new test program, press **<Calib>**. The available programs menu will be displayed.

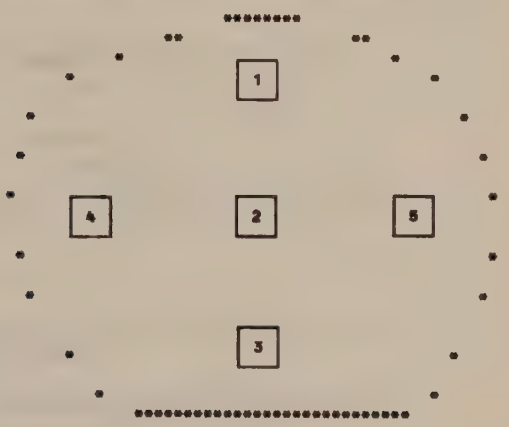
Measuring with Site Locator Map

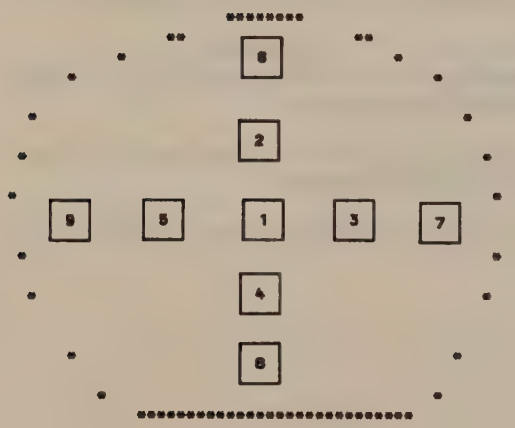
If the site locator map feature has been enabled in the test program you are running, one of the following maps will appear on your screen.

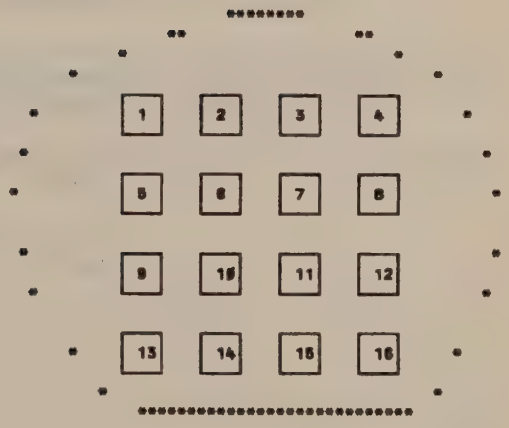
Following the instructions displayed on the screen:

1. Move the stage to the correct location as shown on the map.
2. Press **<Meas>** to measure the film thickness as that site.
3. Repeat the above steps until all sites have been measured.









Messages

While the Models 210/210VT/210UV are taking measurements, you generally will see actual film thicknesses listed in the table in the Measurement Results Window. However, when the measurement is not within spec, you might see any of the following messages in place of an actual measurement:

Standard Programs:

Out of Range — The measurement is out of the range of the instrument's computational ability.

Under Range — The calculated thickness is less than the instrument's specified range.

Less than 100 A — The measurement could be less than 100 angstroms.

Less than 20 A — The measurement could be less than 20 angstroms. This message can appear when measuring thin films with Programs 7 and 8.

Note: For accurate thin film measurements, use the VT option on unpatterned wafers and use the UV option on patterned wafers.

User Defined Programs:

Above Spec Maximum — The measurement was above the user-specified maximum. This is a warning only and does not cause the measurement to be rejected.

Below Spec Minimum — The measurement was below the user-specified minimum. This is a warning only and does not cause the measurement to be rejected.

Above Histogram Limits — The measurement was above the histogram limits. The measurement is automatically rejected.

Below Histogram Limits — The measurement was above the histogram limits. The measurement is automatically rejected.

In user defined programs, the measurement value is displayed whether or not it is rejected.

Reflectance Mode

Using Test Program 12, Reflectance Mode is slightly different than the other programs. This program measures the amount of light reflected from a sample at up to 3 user specified wavelengths. This program can be used to learn the characteristics of a material.

1. Select Test Program 12 at the Available Programs Menu. Proceed as usual, entering the sample ID.

2. The following prompt appears:

```
Number of Reflectance Wavelengths? (1-3)
```

   Type the number of reflectance wavelengths at which reflectance will be measured and press **<Enter>**.

3. The following prompt appears:

```
Enter Desired Wavelength (MIN=370, MAX=800)
```

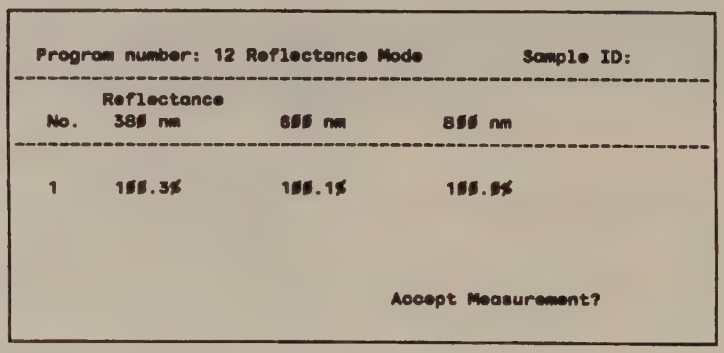
   Type the value of the desired wavelength(s) and press **<Enter>**.

◆ **IMPORTANT**

If any wavelength of less than 460nm is entered, a prompt appears requesting the removal of the yellow filter. Remove if from its position in the vertical illuminator slot just behind the viewing tube assembly.

4. Locate, focus and take a measurement as described in the previous Measurement section.

5. When the measurement is finished, a different Measurement Results screen appears:



6. Proceed as in any other test program, accepting or rejecting the measurement.

Determination of Underlayer Thickness

Five programs analyze dual layer films. They are

Program 4:Polysilicon on oxide
Program 5:Negative resist on oxide
Program 6:Nitride on oxide
Program 11:Positive resist on oxide
Program 253:Non-standard dual layer

In many cases the thickness of the underlayer is known from test wafers or from previously made measurements. Occasionally, it is necessary to determine the thicknesses of both layers simultaneously from a single NanoSpec measurement. The underlayer thickness option enables you to make such determinations easily and conveniently.

1. With the Available Programs screen displayed, press **<F5>**, labeled

   UNDERLAYER
   ON/OFF

   This key toggles the underlayer thickness option off and on. When the option is enabled, the message ***"Calc OX"*** appears near the upper right corner of the screen.

2. Proceed as normal, selecting one of the dual layer programs, 4, 5, 6, 11 or 253.

3. Choose either to measure a new reference or not. After entering a Sample ID, the following prompt appears:

Calculate Oxide Thickness?

   Here you are offered a choice of measuring the underlayer thickness (which need not be an oxide; any dielectric will do, providing the refractive index is specified correctly). Press **<Yes>** to permit the simultaneous determination of the thicknesses of both layers.

4. The following prompt appears:

Enter Oxide Thickness Estimate

   Type your best guess as to what you think the underlayer thickness is and press **<Enter>**. That estimate will be used as a starting parameter in the final determination.

5. The measurement process continues as described in the preceeding Measurement procedures. The Measurement Result screen displays the measurement number I and the film thicknesses t_u and t_l in the format:

$$I\ t_u/t_l$$

Determination of Refractive Index

For single layer films, the NanoSpec makes it easy and convenient to determine both the film thickness and the refractive index (at 633nm).

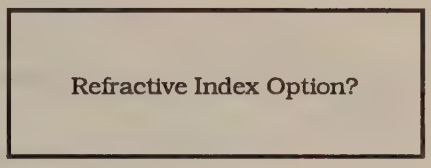
1. With the Available Programs screen displayed, press **<F13>**, labeled

   REF INDEX
   ON/OFF

   This key toggles the refractive index determnation option on and off.

2. The message ***"Calc RI"*** should be displayed in the upper right corner of the screen.

   If the message is not displayed, it will be necessary to enable the refractive index option. To do so, type **RESET** while pressing **<Ctrl>** in order to reinitialize your machine. When the following prompt appears:

   press **<Yes>**. Continue with the initialization. Press **<F13>** when the Available Programs screen is displayed.

3. Select a standard single layer test program. The refractive index option works only if you use on of the standard single layer films; the option is ignored if you choose a dual layer test program or if you use program 254.

4. After enter the Sample ID the following prompt appears:

   Press **<Yes>** to confirm that you want to calculate the refractive index.

5. The measurement process continues as described in the preceding Measurement procedures. The Measurement Result screen displays the measurement number **I** and the film thicknesses **t** and the calculated value of the refractive index **n** in the format:

   I t / n

Printing

With the optional 5" strip chart recorder or cleanroom printer, the Models 210/210VT/210UV can print test results.

Enabling the Printer

There are 2 ways to enable the printer. The following steps explain.

1. The printer can be enabled during the initialization process. See the Initialization section in Chapter 2. If enabled, printing will occur automatically as measurements are taken.

2. If the printer wasn't enabled during initialization, press **<Ctrl>** while typing **PRNTR**. This will activate the printer immediately.

   If you would like to disable the printer without reinitializing, press **<Ctrl>** while typing **PRNTR**.

Printout

The printout will be similar to the following:

```
REFR INDEX =  1.46

PROGRAM NUMBER:  7
THIN OXIDE ON SILICON

OBJECTIVE LENS:  50X

SAMPLE ID:


NUMBER      THICKNESS

  1           42 A
  2           42 A
  3           42 A
  4           42 A
  5           42 A
  6           42 A
  7           42 A
  8           42 A
  9           42 A
 10           42 A


 * END OF TEST *
```

When the printer is enabled, the following information is printed for each measurement program used:

Program name
Objective lens
Accepted measurements

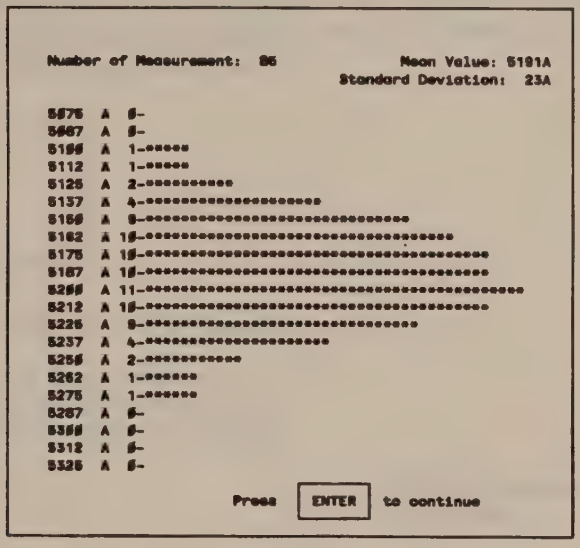
User test program descriptions and statistics are also printed here where appropriate in instrument operation.

Displaying Statistics

The Display Statistics feature is a rapid method for viewing statistics as a test progresses. It may be used with any standard test program or any user defined test. The results are displayed on the CRT screen. This function helps to determine instrument stability or to measure sample uniformity.

1. To display statistics any time during measurement taking, press **<Display Stat>**.

2. The following screen will appear: (it can't be printed)



or, if you are running Program 12 and request several wavelengths, the following screen will appear:

3. Press **<Enter>** to return to normal function form this mode.

Min:	71.8%	25.6%	95.3%
Max:	72.3%	26.6%	96.2%
Mean:	71.6%	26.4%	96.1%
Dev:	.9%	.2%	.1%

4. To erase the statistical information stored in volatile memor, press **<Calib>** or **<New Test>**.

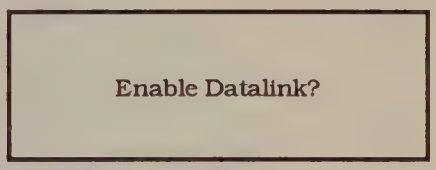
DataLink II

The Models 210/210VT/210UV can be controlled from a remote computer and can transmit their measurements to that computer for analysis through the DataLink II communication channel using the Semiconductor Equipment Communications Standard (SECS II) protocol. Information on SECS II is available in the *DataLink II Communications Manual*, Nanometrics part number 7500-0370.

Information on setting up the parameters for the communication link can be found in Chapter 5, Process Engineer procedures.

Enabling DataLink II

1. DataLink II is enabled during the initialization procedure. The following prompt appears during initialization:

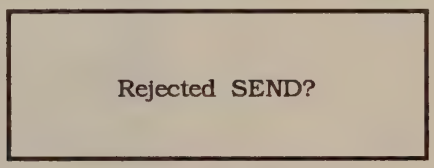


   Press **<Yes>** to enable the communication link

2. To enable DataLink II after initialization is complete (if **<No>** was pressed during the initialization), type **RESET** while pressing **<Ctrl>** to reinitialize the system. Press **<Yes>** when the prompt appears.

Measuring with DataLink II

1. When a measurement is made that is out of range, the following message appears:



   Press **<Yes>** if you wish to send the measurement to the host computer or press **<No>** to not send it.

2. When a valid measurement is taken, or an invalid one is accepted, the following message appears:

Summary

This chapter explained how to use the Models 210/210VT/210UV as an operator. You learned how to run tests. If you are an operator, you now know everything you need to operate the system.

If you are a Process Engineer, the next chapter explains how the Models 210/210VT/210UV determine the thickness of films as well as information of the standard test programs and film types, and Chapter 5 describes process engineering procedures, such as how to define test programs, as well as how to perform . If you are not a process engineer, you should skip these chapters.

For operators, the remainder of the manual contains a system an overview of optional equipment (Chapter 6), what to do if a problem occurs (Chapter 7).

Chapter 4
Technical Overview

This chapter explains how the various components of the Models 210/210VT/210UV work together to produce accurate measurements of your wafers. This information is of particular interest to process engineers who must develop custom film thickness programs.

System Description

The Models 210/210VT/210UV work by reflecting visible light off the surface of a measurement sample through a specially-designed microscope. The visible light source is a regulated halogen lamp or tungsten source that has been optically engineered and focused.

The microscope focuses the light on a precision-engineered diffraction grating which disperses the white light into its component wavelengths (colors), generally over the range of 370 (210 for UV) to 800 nanometers. During operation, the diffraction grating rotates through an arc, causing the light reflected from it to be sequentially scanned from short to long wavelengths across the face of a photomultiplier tube detector. The output of the detector is amplified.

When a reference wafer is scanned in this way, the data obtained from the measurement head consists of four components: the light source, the grating, the detector, and the film. Of these four components, the first three are fixed. The only component that changes is the film.

The analog output of the amplified detector is routed to the metrology computer and converted to a digital signal. The metrology computer applies to this signal to one of several algorithms that take into account the light intensity, the diffraction grating, and the characteristics of the detector, as well as the known characteristics of the film type being measured and the data from an actual measured reference sample. From this, the system computes the thickness of the film.

The principle of determining film thickness from reflectance data is based on the interference caused by the film itself. When a thin film (partially transparent to white light) is measured, part of the light beam is reflected from the surface of the film while some of the beam passes through the film and is reflected by the substrate. (Some of the light is absorbed by the film and the substrate.) If the light reflected by the substrate is in phase with the light reflected by the surface of the film, constructive interference occurs, as shown in Figure 4-1. Otherwise, if the two beams are out of phase, destructive interference occurs, as shown in Figure 4-2. The characteristics

Figure 4-1

Destructive Interference

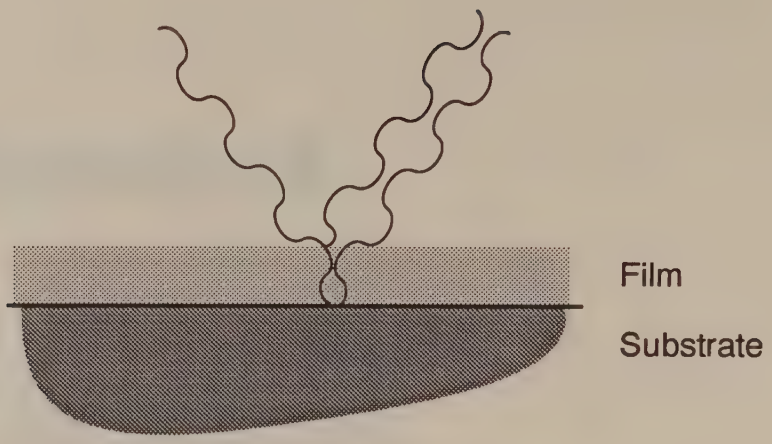


Figure 4-2

Constructive Interference

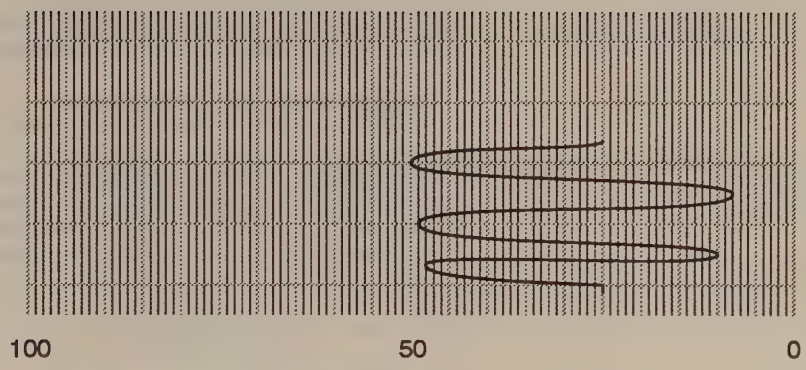
of the interference corresponds to the phase difference between the two reflected beams.

Several factors together determine the extent of constructive or destructive interference. These include:

- The wavelength of the light source
- The film thickness
- The refractive index of the film

Figure 4-3

Typical Interferogram



For a film with a given thickness and a particular refractive index, more light is reflected at some wavelengths than at others. Where reflectance is high, the interference is constructive; where reflectance is low, the interference is destructive. The pattern of high and low reflectances can be plotted for a given film, as shown in Figure 4-3.

All the film thickness programs analyze the interferogram by using curve fitting. The curve-fitting algorithm is highly sensitive to amplitude variations.

Each of the Models 210/210VT/210UV standard programs measures a specific type of film and has particular restrictions on its use.

Notes on Standard Programs

This section lists important information about each of the standard programs. See page 4-10 for a summary chart of information on each program.

Program 1: Silicon Dioxide on Silicon

Use for measuring silicon dioxide on silicon prepared by thermal oxidation. Measurement on highly doped silicon dioxide may be inaccurate because of changes induced in the wafers' optical properties by the doping. For films under 500 Å, use Program 7 which is more accurate in this range. The default refractive index is 1.45.

Program 2: Silicon Nitride on Silicon

Use for measuring silicon nitride that has been chemically deposited on silicon. Measurement of plasma nitrides may be inaccurate because program 2 is designed to measure chemically deposited nitrides. The varying stoichiometry of plasma films can make the measurement uncertain. Frequently, the refractive index (if known) can be used to scale results. For films under 500 Å, use Program 8. The default refractive index is 2.00.

Program 3: Negative Resist on Silicon

The default refractive index is 1.55.

Program 4: Polysilicon on Silicon Dioxide

Research indicates that accurate measurements of thick polysilicon (3,000 Å to 10,000 Å) are highly accurate when the range of underlaying silicon dioxide thickness is between 300 Å and 30,000 Å. Measurement of thin polysilicon (less than 3,000 Å is most accurate when the underlayer thickness is in the range of 800 Å to 1,200 Å. The instrument will display ***"Under-range"*** when measuring polysilicon of less than about 300 Å.

This program assumes undoped Poly and minimal haze. Performance may vary under other conditions. Oxide thickness must be entered with an accuracy of ±100 Å. The default refractive index is 3.975.

Program 5: Negative Resist on Silicon Dioxide

Accurate measurements of negative resist depend on the process engineer entering an accurate underlaying silicon dioxide thickness in the test program. Any error in underlayer thickness results in an error in the measured negative resist thickness. Oxide thickness must be entered with an accuracy of ±100 Å. The default refractive index is 1.55.

Program 6: Silicon Nitride on Silicon Dioxide

Use for measuring chemically deposited silicon nitride. The silicon dioxide thickness must be greater than 100 Å. This program assumes Nitride with Nref = 2.00±0.04. Performance may vary under other conditions. The default refractive index is 2.00.

Program 7: Thin Oxide on Silicon

This program averages data at a specific wavelength rather than scanning through a wavelength range. If the displayed measurement value is more than 700 Å, the wrong program is probably being used. Use Program 1 to make the measurement.

A new reference should be taken whenever selecting this program. When measuring very thin films, take a new reference every 30 minutes or more often. For increased confidence in very thin film measurements, repeat the measurements. The default refractive index is 1.45.

Program 8: Thin Nitride on Silicon

This program averages data at a specific wavelength rather than scanning through a wavelength range. If the displayed measurement value is more than 550 Å, the wrong program is probably being used. Use Program 2 to make the measurement.

A new reference should be taken whenever selecting this program. When measuring very thin films, take a new reference every 30 minutes or more often. For increased confidence in very thin film measurements, repeat the measurements. The default refractive index is 2.00.

Program 9: Polyimide on Silicon

The default refractive index is 1.78.

Program 10: Positive Resist on Silicon

The default refractive index is 1.64.

Program 11: Positive Resist on Silicon Dioxide

The sum of the positive resist thickness and the underlaying silicon dioxide thickness must not exceed 30,000 Å. The Process Engineer must enter an accurately measured oxide underlayer thickness in the test program to avoid errors in positive resist measurements. Oxide thickness must be entered with an accuracy of ±100 Å. The default refractive index is 1.64.

Program 12: Reflectance

Unlike the film thickness programs, this program measures the amount of light reflected from a sample up to three user-specified wavelengths. This program can be used to learn the characteristics of a material so that the information can be used to define custom test programs, or so that the effects of a certain process can be evaluated before and after the process. Use program 12 with the 10X objective only.

In a process using mercury vapor lamps to expose photolithographic resist, wavelengths of 405, 436, and 546 nm should be specified. Mercury vapor produces strong emissions at these wavelengths, and the reflectance of the resist is low since it absorbs light rather than reflecting it. For incandescent lights, wavelengths of 410, 530, and 650 nm might be suitable. Incandescent light emits a continuous spectrum with representative wavelengths in the violet, yellow-green, and red portions of the spectrum.

The reflectance program should be used with the yellow filter removed. All other programs use a yellow filter to reduce sensitivity below 480 nm. At 460 nm, 50% of the light is blocked.

Note that changes in reflectance often result in changes in color (reflected wavelength) which should be taken into account when choosing measurement wavelengths. Measurement time for this program is 2.5 seconds.

Program 13: Thick Films

This program scans the sample from 720 to 770 nm at a slower than normal speed. Note that this change in measurement operation will result in the instrument producing a different sound during operation. Best results are obtained with the 5X objective; however the 10X objective can be used with thinner films having a lower refractive index. Best results are achieved with a range of 4 to 45 microns in thickness.

Program 13 is specified for oxide only; however, this program has proven very useful for other films and substrates whose refractive index has low dispersion as a function of wavelength.

Program 14: Positive Dyed Resist on Silicon

This program was specifically designed for use with Mac-Dermid's EPA914-EZ positive dyed resist. It can be used with the other dyed resists with good results. This program compensates for the presence of the blue-green absorbing dye that gives this high-contrast resist its characteristic red color. However, Program 10 now uses an improved algorithm with extended curve fit ranges that gives maximum accuracy of measurement in all cases.

Model 210VT only:

Program 15: Very Thin Oxide on Silicon

This program uses the 210VT's laser light source to measure film thickness. Make sure the laser beam shutter is open. (Close it when finished.) A reference needs to be taken every 8 hours when measuring with VT.

Program 16: Very Thin Nitride on Silicon

This program uses the 210VT's laser light source to measure film thickness. Make sure the laser beam shutter is open. (Close it when finished.) A reference needs to be taken every 8 hours when measuring with VT.

Model 210UV only:

Program 17: UV Thin Oxide on Silicon

This program uses the 210UV's ultraviolet light source to measure film thickness. It is very important that the D_2 lamp be turned on 15 minutes prior to any measurement (including the reference wafer). Use the 15X reflectance objective lens for all UV measurements.

A reference needs to be taken every 8 hours. Use a calibration sample with a known thickness to take the reference. In thin film measurements, the focus and drift are compensated by software.

Program 18: UV Thin Nitride on Silicon

This program uses the 210UV's ultraviolet light source to measure film thickness. Create a test program to measure the Nitride thickness. It is very important that the D_2 lamp be turned on 15 minutes prior to any measurement (including the reference wafer). Use the 15X reflectance objective lens for all UV measurements.

A reference needs to be taken every 8 hours. Use a calibration sample with a known thickness to take the reference.

Program 19: UV Oxide on Polysilicon on "anything"

Available on the 210UV only, this program uses a ultraviolet light source to measure film thickness. As the ultraviolet light doesn't penetrate the Polysilicon, you can create a test program to measure the Oxide thickness. This is primarily used for Oxide on Polysilicon on Silicon Dioxide. The Polysilicon thickness must exceed 500Å. It is very important that the D_2 lamp be turned on 15 minutes prior to any measurement (including the reference wafer). Use the 15X reflectance objective lens for all UV measurements.

A reference needs to be taken every 8 hours. For best results use the same Polysilicon on "anything" as a reference wafer instead of bare silicon. Take a reference on bare Poly/Ox if measuring Oxide on Polysilicon on Silicon Dioxide.

Program 20: UV Oxide on Aluminum

Available on the 210UV only, this program uses a ultraviolet light source to measure film thickness. Create a test program to measure the Oxide thickness. It is very important that the D_2 lamp be turned on 15 minutes prior to any measurement (including the reference wafer). Use the 15X reflectance objective lens for all UV measurements.

A reference needs to be taken every 8 hours. Take a reference on bare Aluminum. This program assumes good surface smoothness; rough surfaces will degrade repeatability.

Notes on Film Types

Program 253: Doubled layered Films

By using Program 253, the user can customize a test program to measure double layered films that have not been previously defined by Nanometrics. This enables you to measure the thickness of the upper layer of a non-standard dual layer film or of both layers of such a film.

In defining the test program, you are prompted to enter the numerical values of 7 different parameters that describe the refraction, dispersion, and absorption of both films. Let us first consider the top layer, called the "upper" layer. The refractive index of most common films for visible light is given approximately by

$$n = A + B/\lambda^2$$

where A and B are called the Cauchy coefficients. The prompts refer to A and B as "N upper A" and "N upper B", respectively. A common dual layer film is polysilicon on silicon dioxide (which is actually a standard film type given in Program 4, but we will use it here as an example of a special dual layer film). Appropriate values for polysilicon might be:

N upper A:	3.2871
N upper B:	281152

The next 3 parameters describe the absorption of the upper layer. Empirically we have found that the absorption of the polysilicon is given approximately by the expression

$$k = K_a/(K_b-\lambda)^2 - K_c$$

For polysilicon these parameters have approximate values of

K upper A:	3000
K upper B:	340
K upper C:	0.004

If your film is an ordinary dielectric (for which absorption is negligible), just enter 0 for all 3 parameters. The last 2 parameters specify the Cauchy coefficients for the underlayer. Again using our example, appropriate values for silicon dioxide are:

N lower A:	1.4467
N lower B:	3853.

Program 254: Single Layered Films

By using Program 254, the user can customize a test program to measure single layered films that have not been previously defined by Nanometrics. This enables you to measure the thickness of a nonstandard single layer film.

Information on "N upper A" and "N upper B" can be found in the above description of Program 253.

Program 255: Special Film Type

This is a special film program for substrates of 5mm maximum thickness other than Silicon. See Chapter 5, page 12 for more information.

The following chart shows the measurement specifications for the different programs:

210 Film Types Measured	Objective Lens	Range (Å)	Repeatability	Notes
1. Silicon/Dioxide on Silicon	5X 10X, 15X 50X	500-50,000 500-40,000 500-15,000	2Å	
2. Silicon/Nitride on Silicon	5X 10X, 15X 50X	500-40,000 500-30,000 500-12,000	2Å	
3. Non-absorbing Negative Resist on Silicon	5X, 10X, 15X 50X	500-40,000 500-15,000	2Å	
4. Polysilicon on Oxide Polysilicon measurement	5X, 10X, 15X 50X	Poly: 100-15,000 Oxide: 100-10,000 Poly: 100- 5,000 Oxide: 100-10,000	2Å 2Å	1,2,3 1,2,3
5. Negative Resist on Oxide Resist measurement	5X, 10X, 15X 50X	Resist: 400-30,000 Oxide: 100-10,000 Resist: 400-15,000 Oxide: 100-10,000	2Å 2Å	1,3 1,3
6. Nitride on Oxide Nitride measurement Simultaneous Nitride and Oxide measurement	5X, 10X, 15X 50X 5X, 10X, 15X	Nitride: 200-30,000 Oxide: 100-10,000 Nitride: 200-12,000 Oxide: 100-10,000 Nitride: 200-30,000 Oxide: 100-10,000	2Å 2Å 8Å	1,3,4 1,3,4 1,3,4
7. Thin Oxide on Silicon	5X, 10X, 15X	150-500	2Å	
8. Thin Nitride on Silicon	5X, 10X, 15X	150-500	2Å	
9. Non-absorbing Polymide on Silicon	5X, 10X, 15X 50X	500-30,000 500-10,000	2Å	
10. Non-absorbing Positive Resist on Silicon	5X, 10X, 15X 50X	500-40,000 500-15,000	2Å	
11. Non-absorbing Positive Resist on Oxide Resist measurement	5X, 10X, 15X 50X	Resist: 400-40,000 Oxide: 100-10,000 Resist: 400-15,000 Oxide: 100-10,000	2Å 2Å	1,3 1,3
12. Reflectance Mode	5X, 10X, 15X	370-800 nm	0.7%	7
13. Thick Films	5X	4-25 micron	1%	5
14. Red Resist on Silicon	5X, 10X, 15X 50X	4,000-30,000 4,000-15,000	2Å	6

The following chart shows the measurement specifications for the additional film types available with the 210VT:

210VT Film Types Measured	Objective Lens	Range (Å)	Repeatability	Notes
15. Very Thin Oxide on Silicon	5X & 10X	20 - 450	1Å	
16. Very Thin Nitride on Silicon	5X & 10X	20 - 450	1Å	

The following chart shows the measurement specifications for the additional film types available with the 210UV:

210UV Film Types Measured	Objective Lens	Range (Å)	Repeatability	Notes
12. Reflectance Mode	15X	200-800nm	0.7%	7
17. Very Thin Oxide on Silicon	15X	50-150	1.7Å	
18. Very Thin Nitride on Silicon	15X	10-150	1.0Å	
19. Oxide on Polysilicon on Oxide	15X	300-20,000	1.7Å	8
20. Oxide on Aluminum	15X	1500-20,000	5.0Å	9

Notes:

1. Oxide thickness must be entered with an accuracy of ±100Å.
2. Assumes undoped Poly and minimal haze. Performance may vary under other conditions.
3. For the 5X and 10X objective, 1,000Å < total optical thickness of the stack < 60,000Å. For the 50X objective, 1,000Å <total optical thickness of the stack < 27,000Å. (The total optical thickness of a film with thickness T and refractive index N_f is T x N_f.
4. Assumes Nitride with Nref = 2.00±0.04. Performance may vary under other conditions.
5. Specification is for Oxide only; however, this program has proven very useful for other films and substrates whose refractive index has low dispersion as a function of wavelength.
6. Specification is for EPA914 Resist. Performance with other Resists may vary.
7. Measurement time at 2.5 seconds.
8. Polysilicon thickness must exceed 500Å.
9. Assumes good surface smoothness; rough surfaces will degrade repeatability.

Chapter 5
Process Engineer Procedures

Some functions of the Models 210/210VT/210UV are protected so that only persons with the proper authorization can access them. This prevents operators and casual users from modifying test programs, changing or erasing data files, or intentionally or unintentionally corrupting the system. These procedures are collectively known as Process Engineer Procedures and are explained in this chapter.

The information in this chapter is intended for Process Engineers and system managers; in other words, those who are responsible for the accuracy of the instrument and the test programs that are run on it. Topics covered in this chapter include:

- ✔ Process engineer responsibilities
- ✔ Test Programs
- ✔ Specifying Special Films
- ✔ Site Locator Maps
- ✔ Statistics gathering and viewing

Before you attempt to perform the procedures in this chapter, you should become thoroughly familiar with the instrument by performing the operator procedures in Chapters 2 and 3. In particular, you must know how to turn on and initialize the instrument, take a reference, run a test, and display and print data and generate maps.

Process Engineer Responsibilities

As the person ultimately responsible for the accuracy of measurements and thus the quality of a product, the process engineer must be able to ensure the proper operation of the test instruments and verify the accuracy of their measurements. In relation to the Models 210/210VT/210UV, the process engineer has the following responsibilities:

- ✔ Creating and evaluating test programs to meet the needs of the facility and to accommodate the particular fab processes.
- ✔ Instructing operators in the proper use of the instrument with both the standard and user-defined test programs, as appropriate.
- ✔ Setting up statistics parameters for historical evaluation of measurement statistics.
- ✔ Contacting Nanometrics support personnel when instrument maintenance or metrology assistance is required.

Test Programs

A test program contains the instructions necessary to take measurements on a wafer. Information on standard test programs can be found in Chapter 4.

The following functions can be performed by the Process Engineer:

Displaying available test programs

Creating/changing test programs

Printing test program parameters

Erasing a test program

Erasing all test programs

Displaying Available Programs

Displaying a list of all available programs allows the Process Engineer to see which program numbers are in use. This is helpful for selecting a program number to creating or editing a test program. To display a menu of all test programs, follow these steps:

1. Begin at the Available Programs screen. If this screen is not displayed, press **<Calib>**.

2. To access the Setup Mode for Test Programs, type **SETUP** while pressing **<Ctrl>**. The Setup menu appears:

```
                    Setup Mode Choice

  N:   To Display All Programs
  D:   To Display a User Program's Parameters
  P:   To Print a User Program's Parameters
  C:   To Create or Change a User Program
  E:   To Erase a User Program
  R:   To Reset All User Programs

  Enter Your Choice: D                Press CALIB to exit
```

3. Press **<N>** to display all test programs. The following screen appears:

```
                    Available Programs

-------------------------------------------------------------------
Standard programs          User defined programs
-------------------------------------------------------------------

 1 Oxide on Silicon        51   unused        67   unused
 2 Nitride on Silicon      52   unused        68   unused
 3 Neg Resist on Silicon   53   unused        69   unused
 4 Polysilicon on Oxide    54   unused        70   unused
 5 Neg Resist on Oxide     55   unused        71   unused
 6 Nitride on Oxide        56 E-BEAM RESIST   72   unused
 7 Thin Oxide on Silicon   57   unused        73   unused
 8 Thin Nitride on Si      58   unused        74   unused
 9 Polyimide on Silicon    59   unused        75   unused
10 Pos Resist on Silicon   60   unused        76   unused
11 Pos Resist on Oxide     61   unused        77   unused
12 Reflectance Mode        62   unused        78   unused
13 Thick films             63   unused        79   unused
14 EPA914EZ Resist on Si   64   unused        80   unused
                           65   unused        81   unused
                           66   unused        82   unused

                Press [ ENTER ] to continue
```

4. After viewing the available programs, press **<Enter>** to return to the Setup menu.

Creating/Editing a Test Program

To create a new test program or edit an existing one, follow these steps: Enter only a numerical value in this field; do not enter measurement units.

1. Begin at the Available Programs screen. If this screen is not displayed, press **<Calib>**.

2. To access the Setup Mode for Test Programs, type **SETUP** while pressing **<Ctrl>**. The Setup menu appears:

```
                    Setup Mode Choice

N:   To Display All Programs
D:   To Display a User Program's Parameters
P:   To Print a User Program's Parameters
C:   To Create or Change a User Program
E:   To Erase a User Program
R:   To Reset All User Programs

Enter Your Choice: D                Press CALIB to exit
```

3. Press **<C>** to create or edit a Test Program. The following prompt appears:

```
Enter User Program Number:
```

To create a new test, enter the number of the unused test and press **<Enter>**. To modify an existing text, enter its program number and press **<Enter>**.

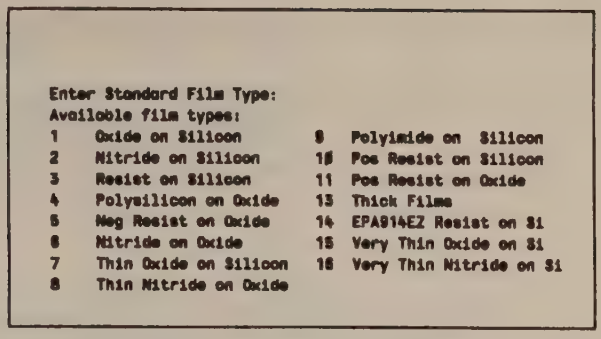
NOTE: If you are modifying an existing program, the current values are provided. Press **<Enter>** if you want to keep the original.

4. **Test Name:**
You are prompted to name the new Test Program:

```
Enter User Program Name:
```

Specify a test name by typing up to 17 alphanumeric characters in the space provided. Press **<Enter>** to complete your entry and move to the next field.

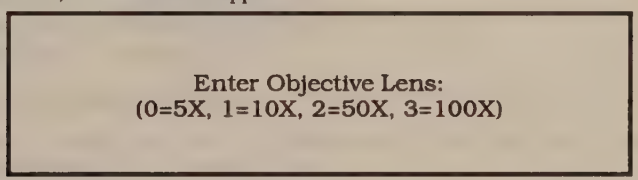
5. **Film Type**
The Film Type menu appears:


Enter Standard Film Type:
Available film types:
1 Oxide on Silicon
2 Nitride on Silicon
3 Resist on Silicon
4 Polysilicon on Oxide
5 Neg Resist on Oxide
6 Nitride on Oxide
7 Thin Oxide on Silicon
8 Thin Nitride on Oxide
9 Polyimide on Silicon
10 Pos Resist on Silicon
11 Pos Resist on Oxide
13 Thick Films
14 EPA914EZ Resist on Si
15 Very Thin Oxide on Si
16 Very Thin Nitride on Si

Specify one of the standard film types by typing its corresponding number, or specify "Special Film Type" by typing **255**. Use film types 253 and 254 to create a test program to measure film types that are not defined in 1 - 20. Press **<Enter>** to complete your entry. Complete information on defining tests with "Special Film Type" and Film Types 253 and 254 begins on page 5-12.

If your system is the 210VT, Film Types 15 and 16 are for VT applications . If your system is the 210UV, Film Types 17 - 20 are displayed. Select one for your UV application.

6. **Objective Lens:**
At this item, the Lens Menu appears:

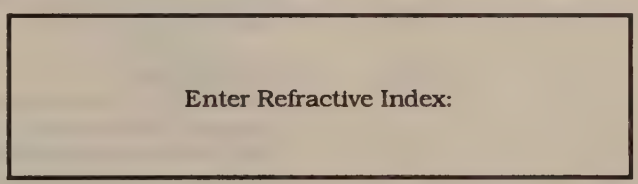


Select an objective lens. Press **<Enter>** to complete your entry. The choice for objective lens is not made by the operator when running a user program.

Note: The 210UV will not have the 100X objective lens.

◆ **IMPORTANT:** It is very critical that the objective lens specified in the program is physically selected on the system prior to taking measurements.

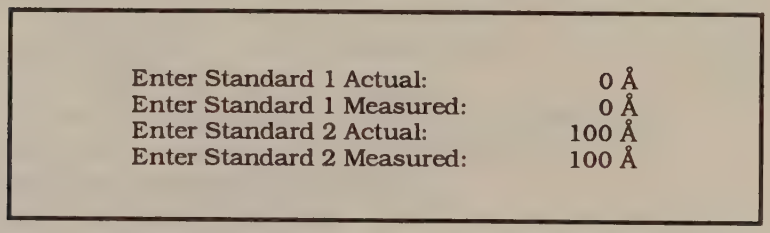
7. **Refractive Index**
The following prompt appears:



The instrument automatically selects a refractive index for standard film types, based on the average value for the film type. If desired, type a value closer to the actual (observed) refractive index for the film and press **<Enter>**.

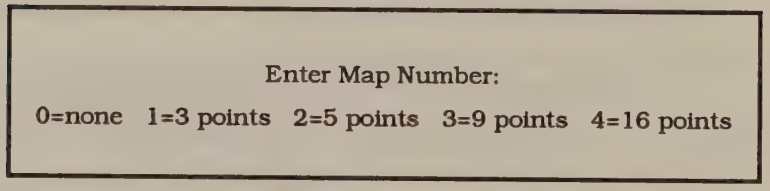
8. **Calibration Slope and Offset:**
These items specify the calibration constants to offset measurements of this instrument so they correspond to measurements taken by another instrument or to measurements of a known standard film. The NanoSpec/AFT automatically applies two-point calibration to all user defined programs.

If no change in calibration is desired, Standard 1 Measured and Actual values should be the same. The Standard 2 Measured and Actual values should also be the same, but they must be larger or smaller than those of Standard 1. Further instructions for calibrating test programs is given on page 5-16.



Standard 1 Actual/Measured
Standard 1 ACTUAL is the *known* thickness of a film in the low end of a range.
Standard 1 MEASURED is the *measured* thickness of that same film.
Standard 2 Actual/Measured
Standard2 ACTUAL is the *known* thickness of a film in the high end of a range.
Standard 2 MEASURED is the *measured* thickness of that same film.

9. **Map Number:**
This provides the automatic programming of a measurement cycle for 3, 5, 9 or 16 point locations. The following prompt appears:



More information is found on page 5-17

10. **Spec Minimum:**
This item is the minimum acceptable thickness, in angstroms, for the material being measured. Measurements that are below this value are considered to be 'Out of Spec.' The words **Below Spec Minimum** appear in the Measurement window. Press **<Enter>** to complete your entry. The entered value affects the statistics histogram scaling.

11. **Spec Maximum**
This is the maximum acceptable thickness, in angstroms, for the material being measured. Measurements that are above this value are considered to be 'Out of Spec.' The words **Above Spec Maximum** appear in the Measurement window. Enter only a numerical value in this field; do not enter measurement units. Press **<Enter>** to complete your entry. The entered value affects the statistics histogram scaling.
When you have completed this last step you return to the Setup Menu.

Viewing a Test Program

To view a user defined test program, program numbers 51 - 82, follow these steps:

1. Begin at the Available Programs screen. If this screen is not displayed, press **<Calib>**.

2. To access the Setup Mode for Test Programs, type **SETUP** while pressing **<Ctrl>**. The Setup menu appears:

```
                    Setup Mode Choice

N:   To Display All Programs
D:   To Display a User Program's Parameters
P:   To Print a User Program's Parameters
C:   To Create or Change a User Program
E:   To Erase a User Program
R:   To Reset All User Programs

Enter Your Choice: D                Press CALIB to exit
```

3. Press **<D>** to display a program's parameters. The following prompt appears:

```
Enter User Program Number:
```

4. Type the program number of the test you wish to view and press **<Enter>**. A screen similar to the following appears.

```
Enter User Program Number:        58

      User Program Name:        E-BEAM RESIST
      Standard Film Type:         1$ Pos Resist on Silicon

      Objective Lens:               2   (1=1$X,2=5$X,3=1$$X)

      Standard 1 Actual:            $. A
      Standard 1 Measured:          $. A
      Standard 2 Actual:          1$$. A
      Standard 2 Measured:        1$$. A
      Map Number:                   3
      Spec. Minimum:              51$$ A
      Spec. Maximum:              53$$ A
```

5. When you have completed this last step you return to the Setup Menu. Press **<Calib>** to exit Process Engineer mode.

Printing a Test Program

To print a user defined test program, program numbers 51 - 82, follow these steps:

NOTE: The printer can be enabled at initialization or at anytime by typing **PRNTR** while pressing **<Ctrl>**.

1. Begin at the Available Programs screen. If this screen is not displayed, press **<Calib>**.

2. To access the Setup Mode for Test Programs, type **SETUP** while pressing **<Ctrl>**. The Setup menu appears:

```
                    Setup Mode Choice

N:   To Display All Programs
D:   To Display a User Program's Parameters
P:   To Print a User Program's Parameters
C:   To Create or Change a User Program
E:   To Erase a User Program
R:   To Reset All User Programs

Enter Your Choice: D                Press CALIB to exit
```

3. Press **<D>** to display a program's parameters. The following prompt appears:

```
Enter User Program Number:
```

4. Type the program number of the test you wish to view and press **<Enter>**.

The printout is similar to the following:

```
+-------------------------+
|  PARAMS FOR PROGRAM 56  |
|                         |
|                         |
|  User Program Name:     |
|  E-BEAM RESIST          |
|                         |
|  Standard Film Type:    |
|    1#                   |
|  Pos Resist on Silicon  |
|                         |
|  Objective Lens: 5#X    |
|                         |
|  Standard 1 Actual:     |
|                   # A   |
|  Standard 1 Measured:   |
|                   # A   |
|  Standard 2 Actual:     |
|                1## A    |
|  Standard 2 Measured:   |
|                1## A    |
|                         |
|                         |
|  Spec Minimum:          |
|                5### A   |
|  Spec Maximum:          |
|                5### A   |
|                         |
+-------------------------+
```

5. When printing is complete, the Setup Menu will appear. Press **<Calib>** to exit Process Engineer mode.

Deleting a Test Program

When you no longer need a test program, you can delete it. On a system with many user-defined tests, this frees up space to define more tests. To delete a test program, follow these steps:

1. Begin at the Available Programs screen. If this screen is not displayed, press **<Calib>**.

2. To access the Setup Mode for Test Programs, type **SETUP** while pressing **<Ctrl>**. The Setup menu appears:

```
                    Setup Mode Choice

N:   To Display All Programs
D:   To Display a User Program's Parameters
P:   To Print a User Program's Parameters
C:   To Create or Change a User Program
E:   To Erase a User Program
R:   To Reset All User Programs

Enter Your Choice: D                Press CALIB to exit
```

3. Press **<E>** to erase a test program. The following prompt appears:

```
Enter User Program Number:
```

4. Type the desired test program number, then press **<Enter>**. A message similar to the following appears:

```
Program 56 E-Beam Resist has been erased
```

NOTE: If you decide not to delete the selected test, backspace over the number and type in an unused program number prior to pressing **<Enter>**.

When the Available Programs screen is displayed, the test you specified will no longer appear.

5. You now return to the Setup menu. Press **<Calib>** to exit Process Engineer mode.

Resetting all User Programs

1. Begin at the Available Programs screen. If this screen is not displayed, press **<Calib>**.

2. To access the Setup Mode for Test Programs, type **SETUP** while pressing **<Ctrl>**. The Setup menu appears:

```
                    Setup Mode Choice

N:    To Display All Programs
D:    To Display a User Program's Parameters
P:    To Print a User Program's Parameters
C:    To Create or Change a User Program
E:    To Erase a User Program
R:    To Reset All User Programs

Enter Your Choice: D                Press CALIB to exit
```

3. Press **<R>** to delete **all** test programs. The following prompt appears:

```
Are you SURE you wish
to RESET ALL user programs??
```

4. Press **<Yes>** to erase all user programs or press **<No>** to leave the programs as they are.

5. You now return to the Setup menu. Press **<Calib>** to exit Process Engineer mode.

Specifying Special Films

In addition to the predefined film types available in the film type menu, you can define tests for special film types.

Program 255

Program 255 permits the determination of the thickness of non-standard single layer films such as resists or oxides on metallic substrates. This program requires the Process Engineer to enter measured values of the maximum and minimum reflectance of the sample or of a similar sample having a film of a different thickness.

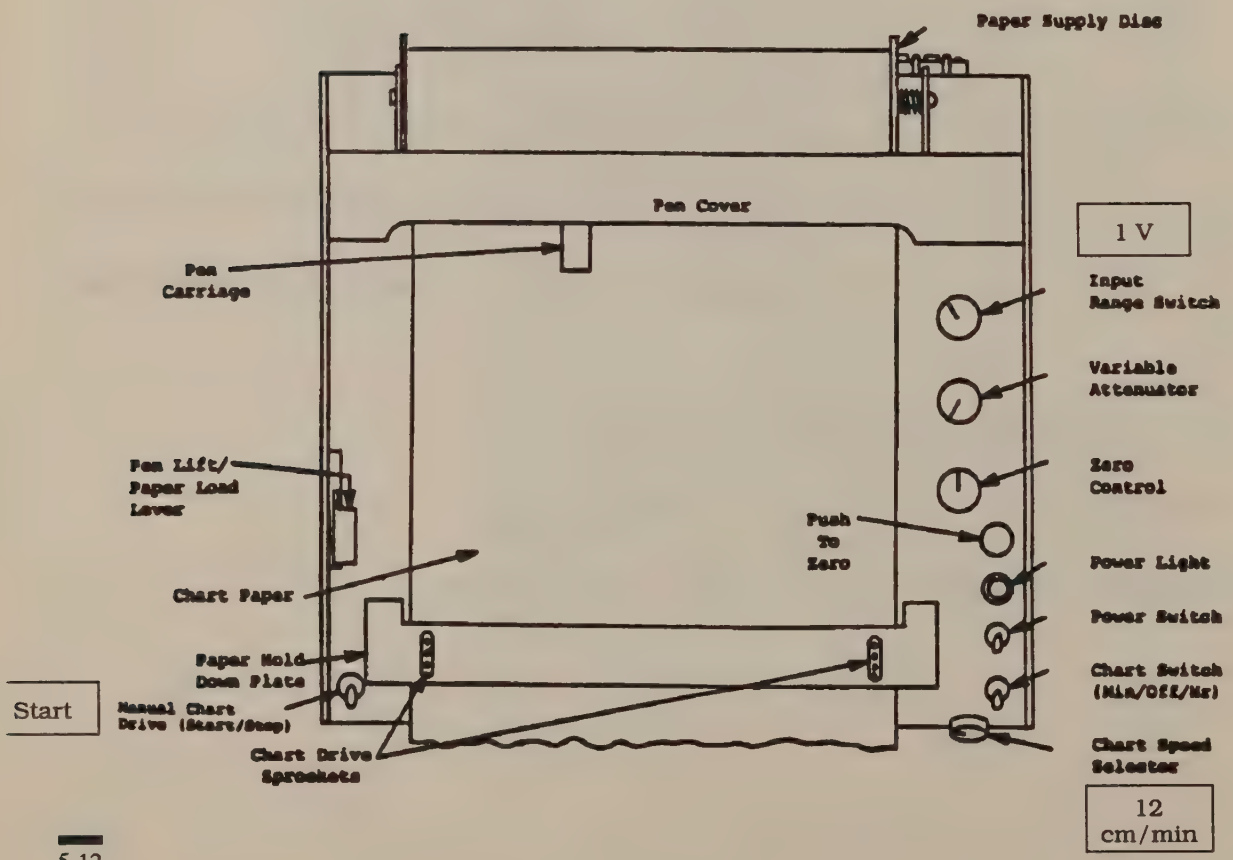
If the film you wish to measure is thick enough to have a peak and valley, the software can determine the maximum and minimum reflectances. Otherwise, the Process Engineer must perform the following procedure to determine the reflectance values.

Determining Reflectance Values

If the film on the wafer you wish to measure is too thin to have a peak and a valley, you must utilize a wafer with a similar sample having a film thick enough to have a peak and a valley. Its refractive index must be known. Use a chart recorder to determine the maximum and minimum reflectances.

1. Beginning at the Available Programs screen run Test Program 1. Type **1** and press **<Enter>**. Select the desired objective lens and press **<Enter>**.

2. Turn on the chart recorder and set the controls:



3. Press the button labeled **PUSH** [a small button on the right top] and hold it down while performing Step 4.

4. Adjust the Recorder Zero Control until the pen is at 0 [the right side of the graph] on the chart paper.

5. Focus the microscope on a bare silicon reference. The following prompt appears:

```
Scan NEW Reference?
```

   Press **<Yes>** and perform a reference. See Chapter 3 for information on referencing.

6. After referencing, run the test on the same bare silicon reference. Press **<Meas>** to start a scan on the chart recorder.

7. Adjust the chart recorder pen with the Variable Attenuator control [the middle knob on the right] for one-half full scale [50% on the chart paper] corresponding to 100% reflection, while the scan is underway.

8. Remove the reference and place the non-standard wafer on the stage. The refractive index of the film must be known. Press **<Meas>** again to start a scan on the recorder.

9. Note the maximum and minimum percentage reflectances observed on the chart recorder. At least one peak and one valley must be seen. If the peaks and valleys have various amplitudes, determine the average maximum and minimum. [Remember that each division on the chart is 2%.]

Creating a Test Program

1. Begin by defining a test program, following the instructions that begin on page 5-4.

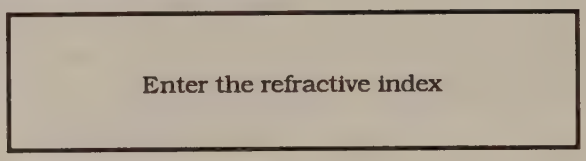
2. For film type, select **255. Special Film Type.**

3. When the following prompts appear:

```
Enter % Reflectance Max:
Enter % Reflectance Min:
```

   Enter the values determined in the above procedure. If the film you wish to measure with this test you are creating is thick enough to have a peak and a valley and you know the refractive index of your film, press **<Enter>** to move through these 2 prompts.

4. The following prompt appears:



   Enter the refractive index of the non-standard film and press **<Enter>**. The last 3 prompts disappear from the screen.

5. Complete the test program definition by specifying the remaining values.

6. Press **<Calib>** to exit Process Engineer mode.

Programs 253 & 254

By using either Film Type 253 or 254, the user can customize a NanoSpec/AFT station to measure films that are not built into the system at the factory. Film type 253 can be used to measure a double layered film and Film Type 254 can be used to measure a single layer film.

The system is currently set up to measure Silicon on Oxide for Film Type 254 and Poly on Oxide for Film Type 253.

Creating a Test Program

See Chapter 4 for more information on the Cauchy Coefficients that are involved in Film Types 253 and 254.

1. Begin by defining a test program following the instructions that begin on page 5-4.

2. For film type, select either **253. double layered film** or **254. single layered film**.

3. Proceed to Step 4 if you are using Film Type 254. **For Film Type 253**, you are prompted to enter the numerical values of seven different parameters that describe the refraction, dispersion, and absorption:

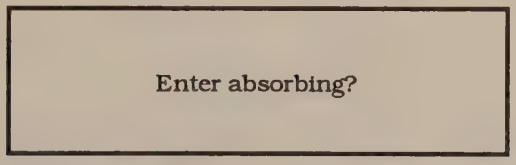
   N upper A:
   N upper B:
   K upper A:
   K upper B:
   K upper C:
   N lower A:
   N lower B:

   Proceed to Step 5 unless you are using Film Type 254.

4. **For Film Type 254**, you are now prompted to enter the numerical values of two different parameters that describe the optical constants:

   N upper A:
   N upper B:

   After entering the Cauchy A and B parameters, the following prompt appears:

   If your film is partially absorbing, press **<Yes>**; otherwise press **<No>**. Most users will not have strongly absorbing films and thus should press **<No>**.

5. Complete the test program definition by specifying the remaining values.

6. Press **<Calib>** to exit Process Engineer mode.

Calibrating a Test Program

This section explains how to calibrate individual test programs. By using this two-point calibration method, the Models' 210/210VT/210UV measurements can be fine-tuned to match the measurements taken on another instrument, or to make it consistent with a known calibration standard wafer. Calibration values are specified for individual test programs. There is no global calibration setting for the Models 210/210VT/210UV.

To determine the values to enter in the Test Editor window, follow these steps:

1. Obtain two thickness values from a given point on two wafers—a low value and a high value. These values can either be values measured on another instrument or values from a known set calibration wafers. The larger the difference between these two values the more accurate the calibration will be. The low value is the **CAL 1 ACTUAL**; the high value is the **CAL 2 ACTUAL**.

2. Obtain two thickness values for the same spots on the same wafers by actual measurements on the Models 210/210VT/210UV. The value from the thinner material is the **CAL 1 MEASURED**; the value from the thicker material is the **CAL 2 MEASURED**.

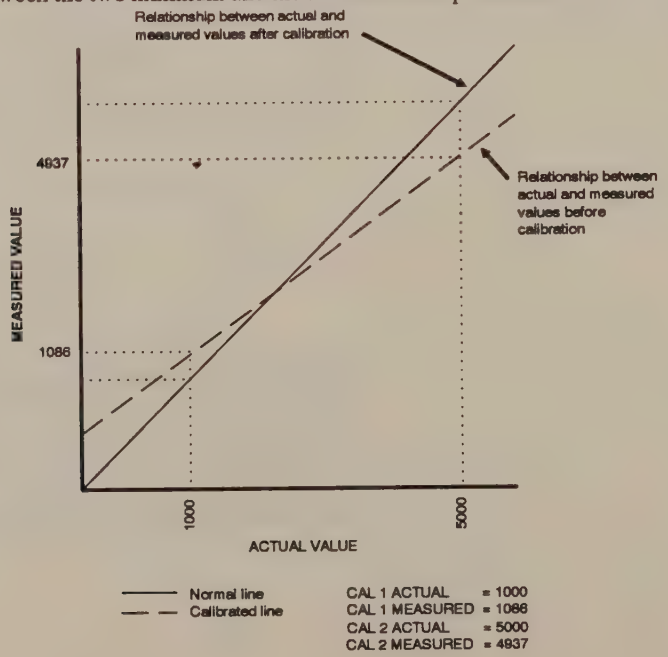
   Actually, it does not matter whether the thicker material is applied to **CAL 1** or **CAL 2**; however, it is critical that the thick measurements and the thin measurements be applied to their corresponding **ACTUAL** and **MEASURED** values.

   The **CAL 1** and **CAL 2** values cannot be the same. The **ACTUAL** and **MEASURED** values can be the same, if no offset is required.

3. Enter the four values in the test program as described on page 5-6.

Further measurements using this test program are linearly offset by the difference between the two minimum and the two maximum points as shown in this figure.

EXAMPLE:

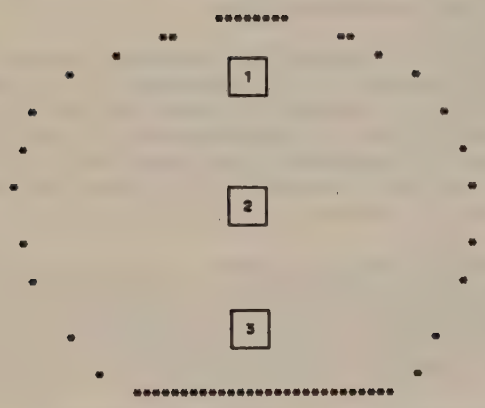


Site Locator Map

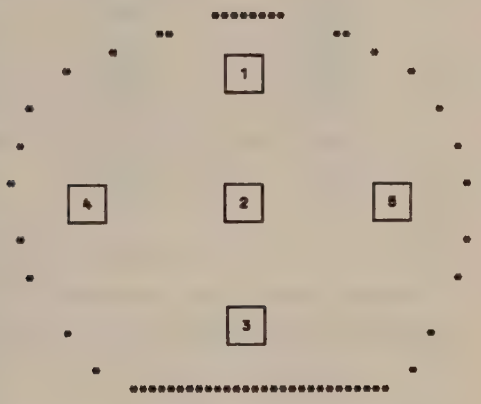
The NanoSpec/AFT Models 210/210VT/210UV include a site locator map that can be included in user-defined programs. This feature consists of four maps with pre-programmed locations for wafer measurement.

This feature is activated in the creation of user-defined programs as explained on page 5-6. It can consist of either 3, 5, 9, or 16 point measurement maps:

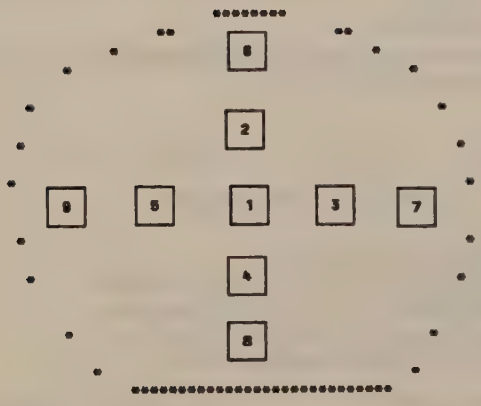
3:



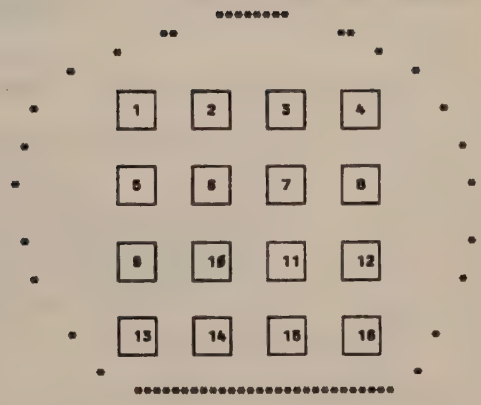
5:



9:



16:



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Statistics Mode

Statistics Mode allows a large number of measurements to be stored in data banks with each user defined program, and displayed in graphic form on the CRT screen. The statistics and histogram may be printed if the printer is enabled.

When measurements are made with a user defined test program, those that are accepted are automatically stored in permanent, nonvolatile memory under that program number. Measurements outside the histogram maximum and minimum are automatically rejected. The statistics, which include the number of measurements and their mean value and standard deviation, are updated with every newly-accepted measurement. Standard deviation does not appear until after the third measurement.

A normalized histogram is also included with the statistics program. It provides a graphical presentation of the measurements. The histogram limits are derived from the specification minimum and maximum defined when the test program is created. The difference between the specified minimum and maximum is divided into 17 equal intervals of at least 1 Å each. Four additional intervals of the same size are established, two above the maximum and two below the minimum, for a total of 21 intervals.

When statistics are displayed, the midpoint thickness value in angstroms or microns appears for each interval in the left-hand column of the display. The number of measurements within each interval is translated into a row of asterisks. The interval with the largest count always extends to the right-hand edge of the CRT screen, and the other rows are scaled proportionally to it.

Displaying Available Programs

Displaying a list of all available programs allows the Process Engineer to see which program numbers are in use. To display a menu of all test programs, follow these steps:

1. Begin at the Available Programs screen. If this screen is not displayed, press **<Calib>**.

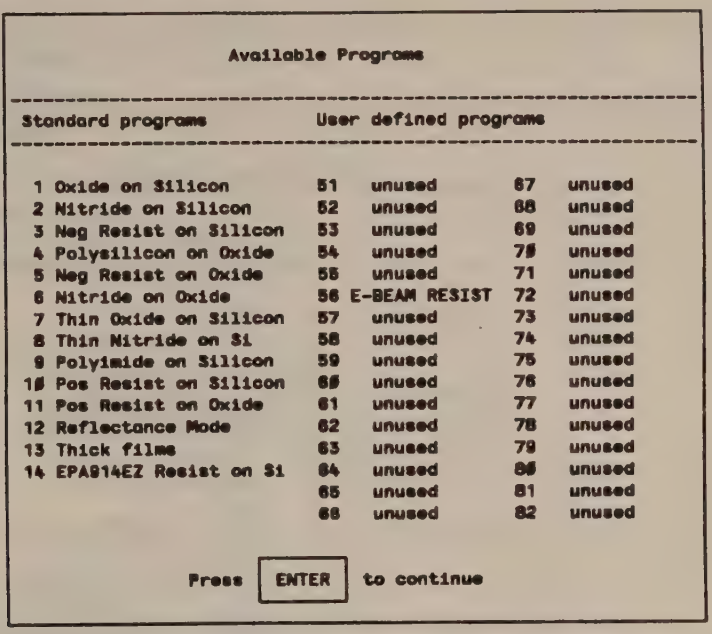
2. To access the Setup Mode for test programs, type **STATS** while pressing **<Ctrl>**. The Statistics Mode menu appears:

```
                Statistics Mode Choices

N:   To Display All Programs
D:   To Display Stats for One User Program
P:   To Print Stats for One User Program
E:   To Erase Stats for One User Program
R:   To Reset All User Program Stats

Enter your choice  N              Press CALIB to exit
```

3. Press **<N>** to display all test programs. The following screen appears:



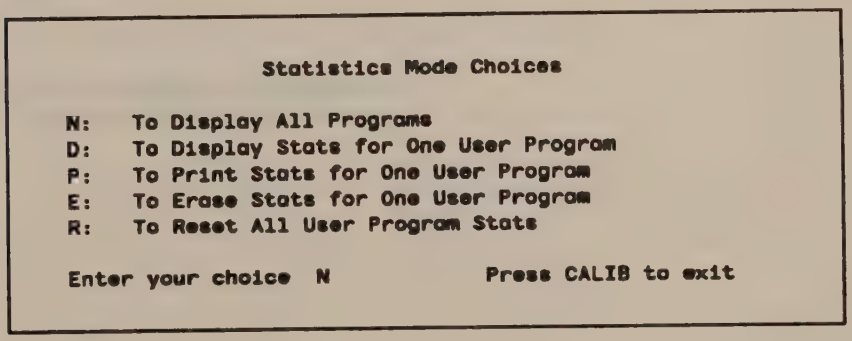
4. After viewing the available programs, press **<Enter>** to return to the Statistics Mode menu.

Viewing Statistics

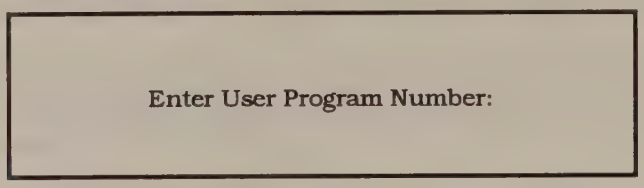
To display the statistics for a user defined test program, program numbers 51 - 82, follow these steps:

1. Begin at the Available Programs screen. If this screen is not displayed, press **<Calib>**.

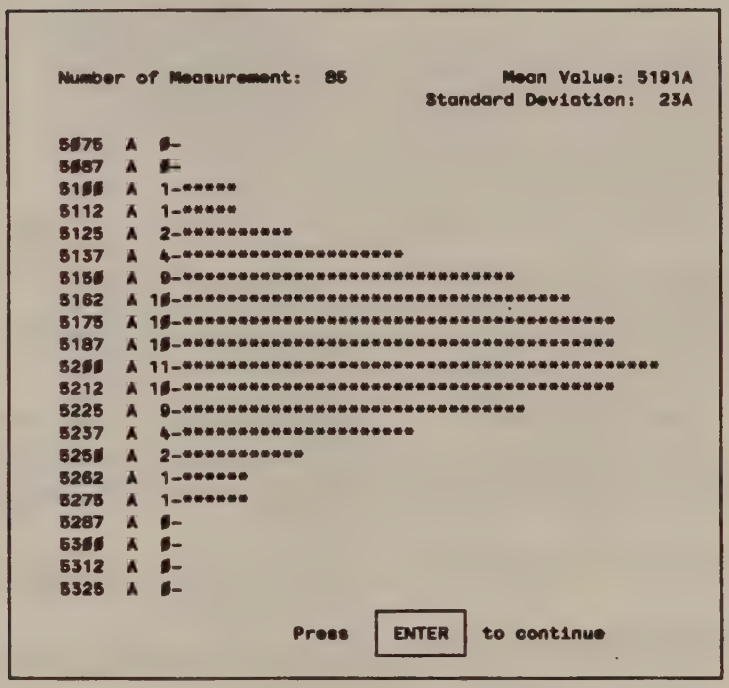
2. To access Statistics Mode, type **STATS** while pressing **<Ctrl>**. The Statistics Mode menu appears:


Statistics Mode Choices
N: To Display All Programs
D: To Display Stats for One User Program
P: To Print Stats for One User Program
E: To Erase Stats for One User Program
R: To Reset All User Program Stats
Enter your choice N
Press CALIB to exit

3. Press **<D>** to display the statistics gathered for a selected test program. The following prompt appears:



4. Type the program number of the test you wish to view and press **<Enter>**. A screen similar to the following appears.



5. When you have completed this last step you return to the Statistics Mode menu. Press **<Calib>** to exit Process Engineer mode.

Printing Statistics

To print statistics for a user defined test program, program numbers 51 - 82, follow these steps:

NOTE: The printer can be enabled at initialization or at anytime by typing **PRNTR** while pressing **<Ctrl>**.

1. Begin at the Available Programs screen. If this screen is not displayed, press **<Calib>**.

2. To access Statistics Mode, type **STATS** while pressing **<Ctrl>**. The Statistics Mode menu appears:

```
                Statistics Mode Choices

N:   To Display All Programs
D:   To Display Stats for One User Program
P:   To Print Stats for One User Program
E:   To Erase Stats for One User Program
R:   To Reset All User Program Stats

Enter your choice  N              Press CALIB to exit
```

3. Press **<P>** to print out a histogram. The following prompt appears:

```
Enter User Program Number:
```

4. Type the program number of the test you wish a print out on and press **<Enter>**.

The printout is similar to the following:

```
+--------------------------+
| Stats for Program 56     |
| E-BEAM RESIST            |
| Measurements:            |
|                85        |
|                          |
| Mean Value:   5191 A     |
|                          |
| Std. Deviation:          |
|                53 A      |
|                          |
|                          |
| Histogram:               |
| 5#75 A              #    |
| 5#87 A              #    |
| 51## A              1    |
| 5112 A              1    |
| 5125 A              2    |
| 5137 A              4    |
| 515# A              9    |
| 5162 A              1#   |
| 5175 A              1#   |
| 5187 A              1#   |
| 52## A              11   |
| 5212 A              1#   |
| 5225 A              9    |
| 5237 A              4    |
| 525# A              2    |
| 5262 A              1    |
| 5275 A              1    |
| 5287 A              #    |
| 53## A              #    |
| 5312 A              #    |
| 5325 A              #    |
+--------------------------+
```

5. When printing is complete, the Statistics Mode menu will appear. Press **<Calib>** to exit Process Engineer mode.

Deleting Statistics

When you no longer need the statistics gathered for a test program, you can delete them. On a system with many user-defined tests, this frees up space for more statistics. To delete the statistics for a test program, follow these steps:

1. Begin at the Available Programs screen. If this screen is not displayed, press **<Calib>**.

2. To access the Statistics Mode for Test Programs, type **STATS** while pressing **<Ctrl>**. The Statistics Mode menu appears:

```
                Statistics Mode Choices

N:   To Display All Programs
D:   To Display Stats for One User Program
P:   To Print Stats for One User Program
E:   To Erase Stats for One User Program
R:   To Reset All User Program Stats

Enter your choice  N              Press CALIB to exit
```

3. Press **<E>** to erase statistics gathered for a specific test program. The following prompt appears:

```
Enter User Program Number:
```

4. Type the desired test program number, then press **<Enter>**. A message similar to the following appears:

```
Stats for Program 56 E-BEAM RESIST have been Reset
```

NOTE: If you decide not to delete the selected test, backspace over the number and type in an unused program number prior to pressing **<Enter>**.

5. You now return to the Statistics Mode menu. Press **<Calib>** to exit Process Engineer mode.

Resetting all User Programs Statistics

Perform this operation only if you wish to erase all of the user program statistics that have been gathered.

1. Begin at the Available Programs screen. If this screen is not displayed, press **<Calib>**.

2. To access Statistics Mode, type **SETUP** while pressing **<Ctrl>**. The Statistics Mode menu appears:

```
                Statistics Mode Choices

N:   To Display All Programs
D:   To Display Stats for One User Program
P:   To Print Stats for One User Program
E:   To Erase Stats for One User Program
R:   To Reset All User Program Stats

Enter your choice  N              Press CALIB to exit
```

3. Press **<R>** to delete **all** of the statistics for **all** test programs. The following prompt appears:

```
Are you SURE you wish
to RESET ALL user programs??
```

4. Press **<Yes>** to erase all statistics or press **<No>** to leave the statistics as they are.

5. You now return to the Statistics Mode menu. Press **<Calib>** to exit Process Engineer mode.

Chapter 6
Overview of Options

The information in this chapter covers the optional equipment available for the Models 210/210VT/210UV, including:

- ✔ Cleanroom printer
- ✔ 100X objective lens
- ✔ Ultra Station
- ✔ 5" strip chart recorder

Chart Recorder

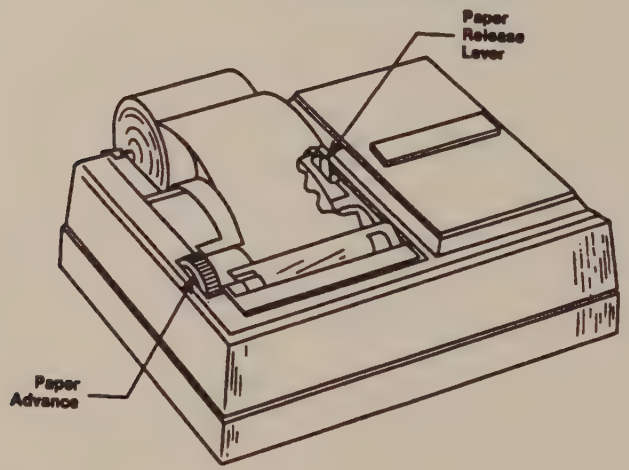
With the chart recorder, the operator can observe the reflectance vs. wavelength scan directly. It is the only means for graphical output.

The Process Engineer should use the chart recorder when designing programs for special films. Minimum and Maximum reflectance data is entered into special tests which produce plotted interferograms useful in determining the type of film being measured and its relative thickness. The chart recorder is necessary for proper use of Program 255 (non-standard films).

To toggle the slow chart output ON and OFF from the Models 210/210VT/210UV, type **SLOWC** while pressing **<Ctrl>**. This slows the output signal from the computer to the recorder, providing an expanded interference curve.

Cleanroom Printer

The cleanroom printer provides printed copies of all measurements.



Paper Advance Thumbwheel

Rotate the white paper advance thumbwheel to move the tape up one line. Movement is limited to one line increments. Use this control to advance the tape before tearing off the printout or to thread a new roll of tape. Tear paper form right to left.

Paper Release Lever

Pull the black paper release lever forward to release the rollers that normally hold the tape against the platen. This allows the tape to be removed at the end of a roll or when the printer has jammed.

100X Objective Lens

A 100X objective lens is available, which allows a nominal 2.5 micron spot size, and thus can measure film elements as small as 3 microns across. Spot size is inversely proportional to lens power. A 10X objective has a 25 micron spot size and cannot reliably measure the thickness of smaller elements. The 100X objective is a dry, not oil immersion, lens.

Use of the 100X objective is limited to measuring films of less than 5,000 Å. Since the photomultiplier tube is especially selected and system tested, this option must be selected when ordering the systems and should not be installed in the field.

This option is not available for the 210UV.

Ultra Station

The Ultra Station is an automated cassette wafer handler used with the Nano-Spec/AFT. It can speed up measurement and throughput, reduce wafer breakage and prevent edge damage to reduce circuit cost. The Ultra Sation can be retrofitted to most existing models.

Chapter 7

Troubleshooting and Service

This chapter is designed to help in troubleshooting for minor problems and to give aids to help service the instrument for satisfactory performance over an extended period of time.

- ✔ Maintenance
- ✔ Troubleshooting
- ✔ Gain and Zero Adjustment
- ✔ Moving the Instrument
- ✔ Disassembly
- ✔ Installation or Reassembly
- ✔ Strip-Chart Recorder Installation

*Maintenance Manuals are available

Maintenance

Preventive maintenance is very important to ensure that your system's measurements are reliable and accurate.

Cleaning the Lenses

Take great care with the objective lenses. Do not allow them to touch or scrape against any surface. The lenses are designed to be resistant to damage, but small particles can stick to their surfaces, causing a loss of resolution. Therefore, examine the objective lenses from time to time with a small magnifying glass. The microscope eyepiece is suitable for this purpose. If dust or dirt appears on the objective lens, clean the lens with a cotton swab dipped in denatured alcohol. **Do not perform this on the 210UV.**

Only if your system is the 210UV:

D_2 Lamp Replacement Procedure

If the D_2 lamp needs to be replaced, proceed as follows:

- ❑ Always wear protective eyeware when securing the instrument or if the lamp is turned on outsie of lamp housing.
- ❑ Make sure the lamp housing is cool to the touch prior to opening. Wear gloves to protect the D_2 lamp.

Removal:

1. Unscrew the 4 screws located at the right hand side of the lamp housing. This will allow you to remove the lamp assembly from the lamp housing.
2. Release the spring or bracket which will unload the D2 lamp. Unscrew the connector from the terminal strip. Remove the entire lamp.

Installation

1. Connect the wire to the terminal strip by matching the color of the wire and terminal.
2. Put the lamp into the socket. Put the spring or bracket on top to secure the lamp.
3. Insert the lamp back into the lamp housing and tighten the screws.
4. Turn the power on and perform the Initialization and Preoperation Procedures for the 210UV found in Chapter 2.

Troubleshooting

This sections contains troubleshooting procedures, consisting of common problems and suggestions for their solution.

Common Problems

Problem 1:

Measurements are not repeatable or photointensity display is unstable. The P.M.T. stabilizing LED must be disabled when checking photo intensity

Possible Solution

1. If power has been off for more than a few minutes, allow the instrument to warm up for 30 minutes after turning the power on.
2. Press **<Ctrl>** while typing **SETGN** to reset the gain.

Problem 2:

When the microscope is focused on a bare silicon reference wafer with the 10X objective, the photointensity reading is less than 65 - 67 at 640nm.

Possible Solutions

1. Ensure that the wafer is clean, with no dust particles or irregularities, and has no oxide or other film on it.
2. Ensure that the microscope lenses are clean.
3. Be sure that the objective is correctly aligned in the turret.
4. Loosen the 3/32 " Allen screw at the left and just above the turret. Ensure that the turret is correctly inserted, then tighten the screw.
5. Adjust the Gain Control until the photo intensity meter reading is between +65.0 and +67.0. Press **<Ctrl>** while typing **RESET** if the system needs to be reset.
6. Check the focus.
7. Check the zero setting (photointensity reading 0.5 to 1.0) by turning the turret to a position between detentes, then adjust the ZERO control if necessary.
8. Check to make sure that the lamp is not burned out.
9. Make sure that the yellow filter is completely in.

Problem 3:

Photointensity cannot be brought up to proper level with Gain Control.

Possible Solutions

1. Check that the lamp switch is on.
2. Ensure that the light bulb is not burned out.
3. Verify that the objective is correctly aligned in the turret.
4. Ensure that the wavelength counter is at 640 nm.

Problem 4:

Illumination of the sample is not centered.

Possible Solutions

1. Ensure that the objective is correctly aligned in the turret.
2. Loosen the 3/32 " Allen screw at the left and just above the turret. Ensure that the turret is fully inserted, then tighten the screw.
3. Ensure that turret is in detented position.

Problem 5:

Unclear or otherwise poor focus.

Possible Solutions

1. Ensure that the microscope lenses are clean.
2. Check the focus of the monocular tube (eyepiece). Loosen the setscrew in the tube, then slide the tube so that the black dot is in the best focus. Tighten the setscrew.
3. Verify that the sample is flat on the stage.

Problem 6:

The wavelength counter reads greater or less than 480 nm in the available programs mode.

Possible Solution

1. Typing **RESET** or **SWAVE** while pressing **<Ctrl>** is equivalent to and more rapid than turning the power switch off and then on. It also does not require a waiting time for the lamp and electronics to stabilize. If this problem happens often, report it to a customer support representative.

Problem 7:

The measurement values obtained are inaccurate or nonrepeatable.

Possible Solutions

1. Recalibrate with a clean, bare silicon reference wafer.
2. Ensure that the yellow filter is in correct position.

Problem 8:

The computer prints *"Out of Range"* when a value was expected.

Possible Solutions

1. Check the focus.
2. Verify that the correct program is being used.
3. Measure a calibrated wafer with a thickness near that of the sample wafer. If *"Out of Range"* is still printed, then recalibrate with a new reference wafer.

Problem 9:

CRT keyboard suddenly becomes inoperative.

Possible Solutions

1. Turn both the lamp and the computer off, and then on again.
2. If this does not work, call a customer support representative. Primary power source may be emitting "noise", which requires a line transient suppressor.

Problem 10:

The list of programs is not displayed, or is garbled.

Possible Solutions

1. The battery protecting the nonvolatile memory is low, or improperly connected. Check the switches on the memory board for the proper setting, and allow a few hours for the battery to recharge.
2. If the battery seems to be functioning properly, call a customer support representative.

If Troubleshooting Fails

Call the Nanometrics Customer Support department at the factory [telephone number (408)746-1600] to discuss the problem to obtain approval for return of the instrument, if necessary.

If customer support personnel cannot diagnose the problem by telephone, request a return authorization number, which is necessary before returning the instrument to Nanometrics for service. See the section on disassembly procedures.

NOTE: To protect the grating in transit, set the wavelength to approximately 1920 nm, as follows: (For the 210UV, set the wavelength to 900.)

1. Turn the power off.
2. Turn the power on.
3. Make sure that the wavelength counter reads 480 or lower.
4. When the computer asks, ***"IS WAVELENGTH 480?"*** press **<No>**.
5. Type **0**.
6. Repeat this procedure two more times.

Gain and Zero Adjustment

If the GAIN and ZERO controls must be adjusted, reach inside the black cover at the right rear of the spectrophotometer head.

1. Wait until the instrument has warmed up (about 30 minutes, if the main power was not previously on).
2. Eliminate all light from the system by rotating the turret to a position between two detentes. (Rotating the turret is better than turning off the lamp. For stable operation the lamp must warm up one or two minutes when turned back on. Furthermore, it does not go out completely when turned "off".)
3. Look at the photointensity reading. It should be quite low, between +0.5 and +1.0. If necessary, adjust the reading with the ZERO control.
4. Return the turret to the 10X objective, with the yellow filter in place.
5. Check the photointensity reading again. It should be between +65.0 and +67.0.
6. Use the GAIN control to set the reading at this level.
7. Turn the turret again to a position between detentes and ensure that the photointensity is again between +0.5 and +1.0.
8. Repeat these operations as necessary until both conditions are satisfied.

◆ **IMPORTANT:** Always allow the instrument to restabilize for five minutes after changing any control settings, and be sure to recheck these meter readings at least once a week. Repeatability may otherwise be degraded.

Moving The Instrument

Ordinarily Nanometrics personnel are available to install the NanoSpec/AFT. The following instructions are included in this manual only for instances when the instrument must be moved and Nanometrics personnel are not available.

Disassembly

1. Turn off the power.
2. Remove the viewing tube by loosening the set screw on the side of the tube, and place it in the molded foam rubber package in which it arrived when the instrument was originally installed. If the package is not available, pack the viewing tube carefully with plenty of padding.
3. Remove all interconnecting cables.
4. Loosen the Allenhead screw on the left below the spectrophotometer head (refer to Figure 6-1), and carefully lift the head assembly off of the vertical illuminator.
5. Remove the lamp housing from the rear of the vertical illuminator.
6. Loosen the thumbscrew on the right side and remove the vertical illuminator.
7. Loosen the 3/32" Allen screw on the left side of the stand and remove the objective turret by sliding it forward.
8. Remove the objectives from the turret. Avoid letting the shims, if any, fall off. If they do, replace them in their original location. Put each objective in the plastic lens case in which it arrived from the factory, or pack it carefully in foam rubber in a stout box.
9. Remove the stage from the semicircular yoke that supports it. It is attached with four metric Allen screws. The two in front must be removed, but the two at the rear of the yoke need only be loosened.
10. Pack each component in an appropriate well padded container for transportation to the new location.

Installation or Reassembly

The spectrophotometer head, microscope, controls and adjustments on the NanoSpec/AFT system are shown in Figure 6-1. Numbers in parentheses (x) in the following paragraphs refer to numbered callouts in the figure.

Do not use tools on any thumbscrews or other components to be tightened; use finger pressure only, unless specified otherwise. Left and right are as seen from the front of the instrument.

1. Install the NanoSpec/AFT on a sturdy table or desk measuring at least 24 by 30 inches (60 by 75 cm) and with a height of about 28 inches (70 cm). The monocular viewer is usable by most people while standing, but for extended use a chair or stool high enough to place the eye at a similar height should \be available.

   The general area should be clean. Take care to protect the microscope optics and mechanical components and the computer from accidental damage, such as spilled liquids, abrasive materials, or corrosive vapors. Do not locate the instrument near acid baths or hot furnaces. Acids can etch the objective lenses and cause poor optical performance.

2. Each microscope stage, whether it is 4", 5", or 6" (1) and the NanoLoader is attached to the microscope in the same way. Four Allen screws secure the stage to a semicircular yoke.

   Remove the two front screws from the bottom of the stage, and loosen the two rear screws. Slide the two rear screws into the slots at the rear of the semicircular yoke. Install the two front screws through holes in the yoke. Tighten all four screws.

3. Push the turret (2) all the way in and tighten the thumbscrew.

4. Screw the objectives into the turret. Install shims that were packed with the objectives.

5. Place the vertical illuminator (3) on the stand in its dovetail, and tighten the thumbscrew (4).

6. Put the lamp housing (5) onto the vertical illuminator shaft, and tighten its thumbscrew.

7. Plug the lamp into the lamp housing.

8. Place the spectrophotometer head (6) on the vertical illuminator, and tighten the Allenhead set screw on the left side of the head support shaft (7).

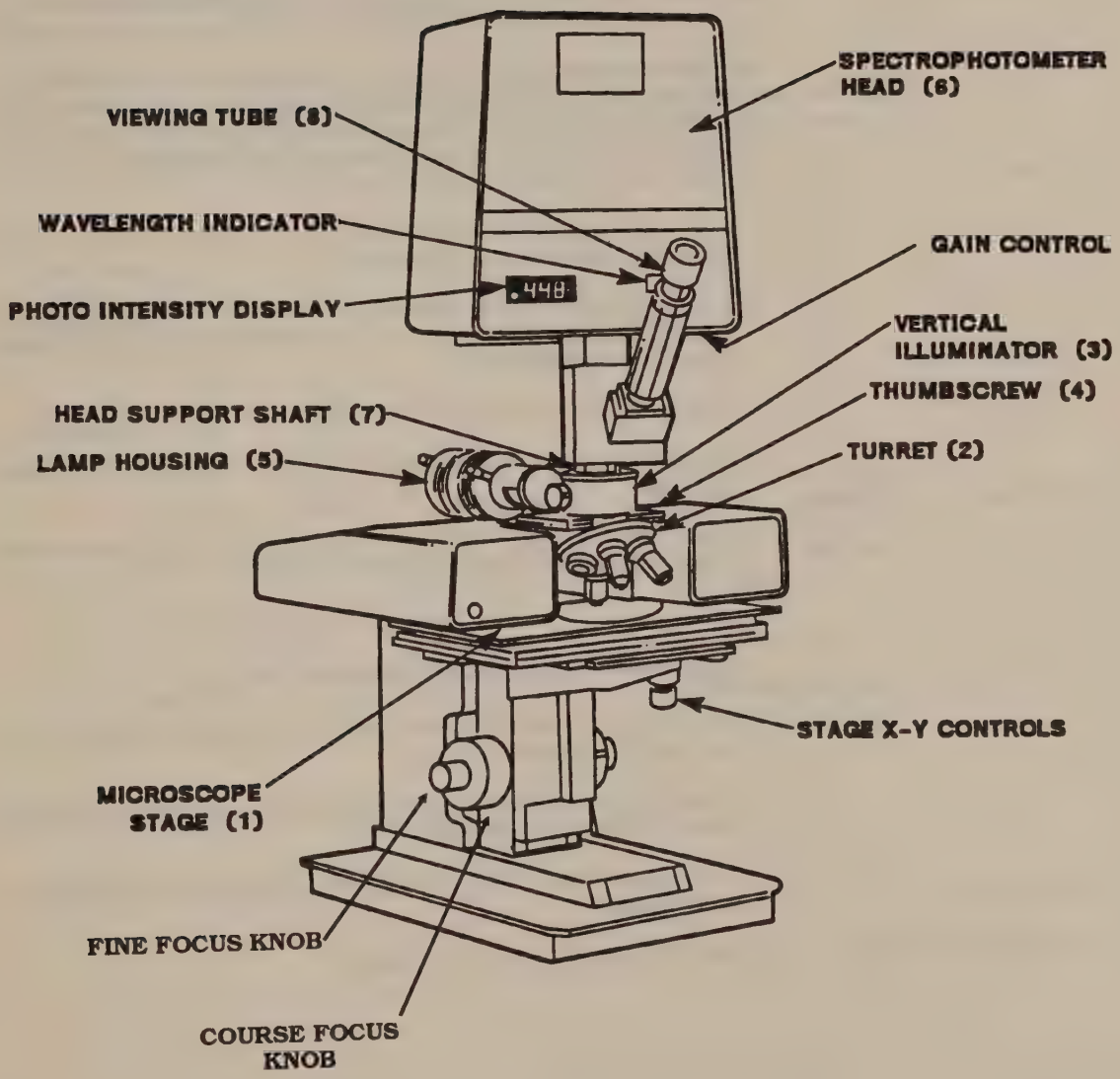

SPECTROPHOTOMETER HEAD (6)
VIEWING TUBE (8)
WAVELENGTH INDICATOR
PHOTO INTENSITY DISPLAY
.448
GAIN CONTROL
VERTICAL ILLUMINATOR (3)
THUMBSCREW (4)
HEAD SUPPORT SHAFT (7)
LAMP HOUSING (5)
TURRET (2)
STAGE X-Y CONTROLS
MICROSCOPE STAGE (1)
FINE FOCUS KNOB
COURSE FOCUS KNOB

Figure 7-1

The accompanying diagram (Figure 6-2) shows the system interconnections. The Autofocus socket is not used.

◆ **CAUTION**

Before connecting any cables, be sure the main cable is disconnected and the computer power switch is off. Serious damage may result if the main power cable is not the last one connected.

9. Two cables connect the spectrophotometer head to the computer: the black cable to the receptacle marked SIGNAL, and the gray cable to the receptacle marked SPECTRO.

10. Connect the CRT terminal signal cable to the 25-pin RS232C connector on the computer, and to the MODEM or EIA (or Main Port) connector on the terminal.

NOTE: The RS232C connector on the back of the computer is set to transfer data at 9600 baud. The interface cable connections are to pins 1, 2, 3, 7, and 20, where pin 20 is high when the terminal is ready. Other RS232C compatible devices can be connected to this port with the same constraints. For other situations, contact the manufacturer of the particular RS232C device.

11. If a stripchart recorder is used, connect its cable to the receptacle marked RECORDER on the back of the computer.

12. Connect the power cable to a primary power source that meets the conditions specified in Chapter 1. Check to see that all other cables are securely in place, and turn the power switch ON.

13. Turn on the microscope lamp with the switch on the rear of the computer.

14. Place the viewing tube (8) on the viewer block shaft. Insert the eyepiece into the view tube.

15. Adjust the position (tube length) of the view tube so that the black center aperture (black dot) is in sharp focus, and tighten the set screw.

If your system is the 210VT, proceed as follows:

1. Connect the signal cable from the VT option to the computer by plugging it into the *"Signal"* plug on the computer.

2. Connect the reference cable from the VT option to the computer by plugging it into the *"Ref"* plug on the computer.

3. Attach the cable from the VT power supply to the plug marked *"indicator"* on the VT option.

4. Plug in the power supply to the VT option.

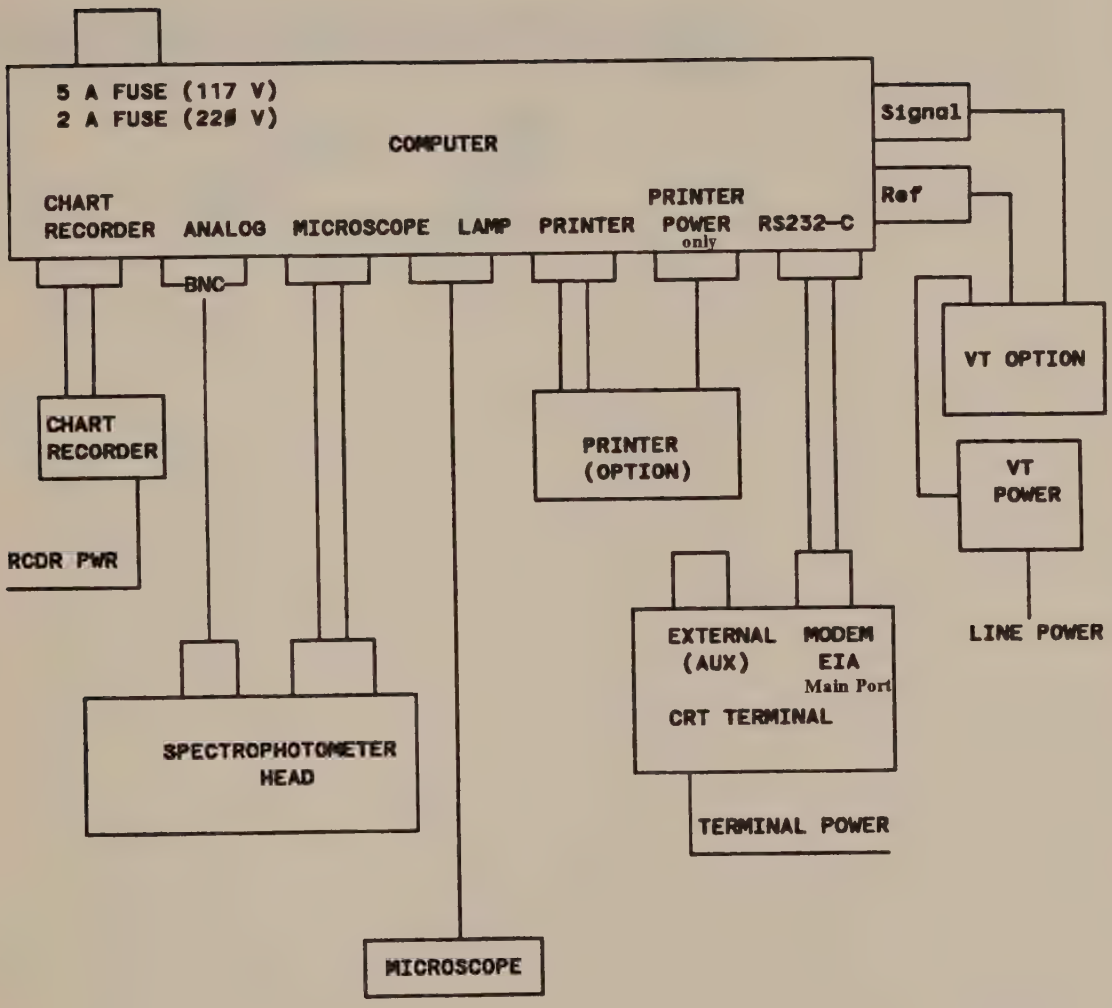


Figure 7-2

Interconnect Diagram

Strip Chart Recorder Installation

This unit is installed in the NanoSpec system with a nine pin connector cable on one end and five spade lugs on the other end.

The nine pin connector plugs into the marked receptacle on the back of the computer. The five spade lugs are connected to the terminal block on the back of the recorder as follows:

RED	to positive
BLACK	to negative
GREEN	to ground
WHITE	to REM
BROWN	to LOG

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